September 1978
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Number 5

# Mariners Weather Log

National Oceanic and Atmospheric Administration • Environmental Data and Information Service

**U.S. DEPARTMENT OF COMMERCE**
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Cover: A spectacular view of a fatal accident. The Algerian freighter IBN BATOUTA pierced the port engineroom side of the American freighter YELLOWSTONE (bottom). The vessels collided in fog in the Straits of Gibraltar on June 12. After separation the YELLOWSTONE sank the next day. See Rough Log June 1978 on pages 371-72. Wide World Photo.

# Mariners Weather Log

**Editor: Elwyn E. Wilson**
**Editorial Assistant: Annette Farrall**

**September 1978**
**Volume 22 Number 5**
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Mariners Weather Log

# THE 1977 - 78 SOUTHERN CALIFORNIA WINTER

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A series of unusually severe winter storms struck Southern California between December 1977 and March 1978. Four of these storm periods, each unique in terms of extreme weather, are highlighted in this article:

A record-breaking, large-scale windstorm in late December;

An unusually high surf in mid-January which did extensive damage to beaches and beach structures;

A killer rain and windstorm in early February triggered flash floods, mudslides, and extensive wind damage; and

Storms in early March which caused stream flooding, mudslides, and wave damage.

## WINDSTORM OF DECEMBER 19-21

On the 19th a deepening eastern Pacific surface LOW and a building plateau HIGH over Idaho began to accelerate easterly winds across much of California. At 1200 on the 20th the surface pressure gradient between the HIGH and the LOW peaked at 62 mb. Figure 1 is an infrared satellite imagery at 1145 of the 980-mb eastern Pacific LOW.

The geostrophic wind approximation applied to the 1200 pressure gradient indicates that winds just above the Earth's friction layer averaged 40 to 50 kn. However, isobaric packing across California was much tighter than this, and channeling by canyons and passes also accelerated the winds to extreme speeds. Peak speeds of 50 to 80 kn occurred at many mountain and nearby coastal locations on the 20th. Gale warnings were required in the San Diego area for the first time in decades.

The strongest, most damaging winds were in Kern County at the southern end of the San Joaquin Valley. Peak 2-s wind gusts were estimated to be 130 kn, while peak 1-min winds approached 115 kn at the site of four downed 500-kilovolt power transmission towers (Gouze and Richmond, 1978). Extensive property damage occurred in the town of Arvin, 15 mi southeast of Bakersfield. Numerous structures were partially or completely destroyed. Most windows were blown out in the town and surrounding areas. Over much of the county, pasture and top soil were stripped off. Trees were downed and crops destroyed. The downed transmission towers caused power disruptions for a day or more. Long-time residents described it as the worst storm ever in the area. The sky was blackened by clouds of dust and debris, requiring the use of vehicle headlights and residential lighting during

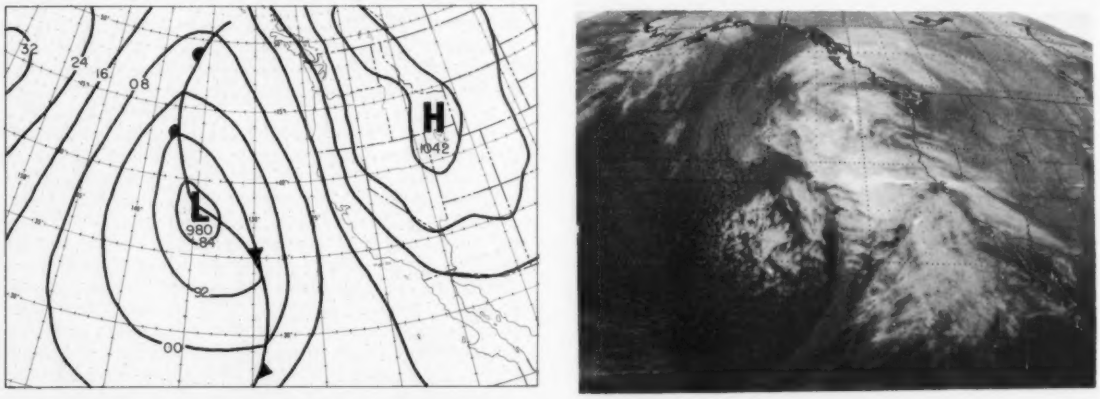



Figure 1.--This deep eastern Pacific LOW coupled with a strong plateau HIGH resulted in the severe California windstorm. The 1200 chart of the 20th shows the synoptic situation.

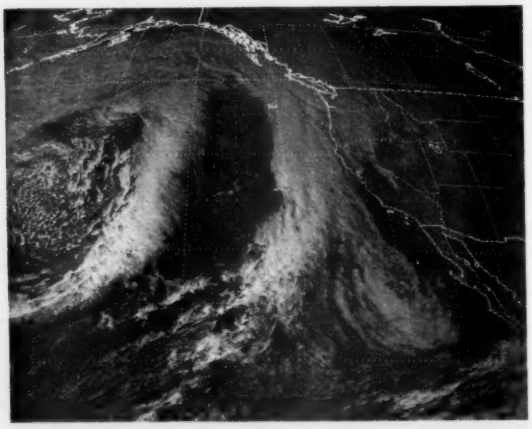
Figure 2.--Strong winds caused extensive damage during the December windstorm. Newhall Signal Photo.

the middle of the day. Air and surface transportation was severely curtailed. Tejon Pass, along Interstate 5, California's main north-south artery, was closed for most of the 20th due to restricted visibility and severe winds. Thousands of vehicles and buildings were damaged or destroyed (fig. 2).

No deaths resulted directly from the storm. However, five people were killed in car accidents caused by reduced visibility in blowing dust. Also, the Base Commander and Fire Chief at Vandenberg Air Force Base in Santa Barbara County were killed when trapped by an extensive brush fire which was spread rapidly by strong, dry offshore winds. Property damage in Kern County alone was estimated at $40 million, about half of it to agriculture. Additionally, heavy damage to citrus and avocado crops in other Southern California counties was reported.

SURF DAMAGE - JANUARY 8-23

The surf damage to beaches and beach structures during January resulted from swell generated by eastern Pacific storms. The visual satellite picture at



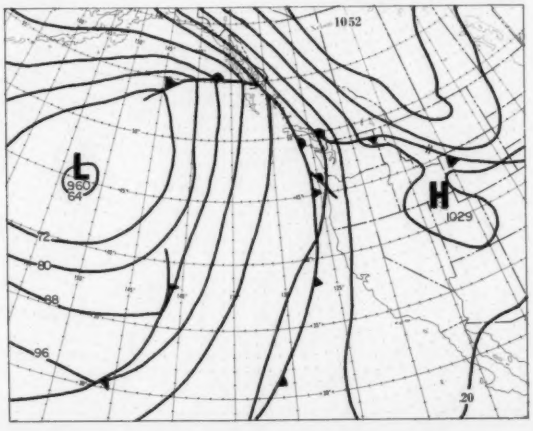



Figure 3.--Two January storms which sent destructive waves to the California coast. The 0000 surface chart of the 8th shows how the synoptic and satellite patterns corresponded.

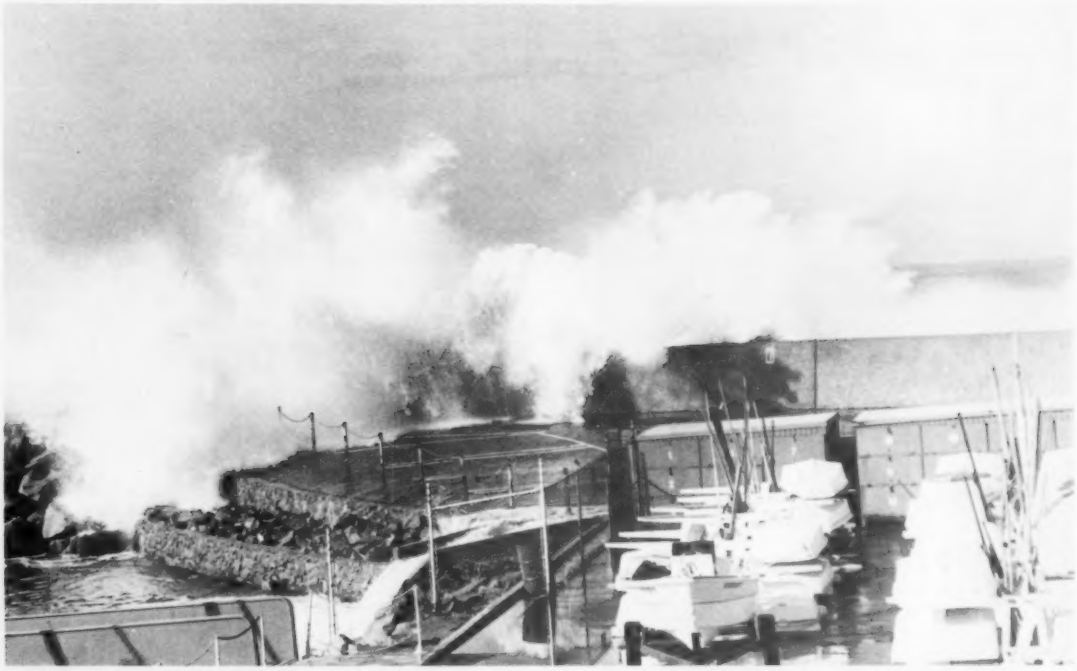


Figure 4.--Large waves battered the seawall at Redondo Beach. U.S. Army Corps of Engineers Photo.

2315 on January 7 (fig. 3) shows two storm systems which generated unusually large swell at low latitudes. The frontal system near the coast was more vigorous a few days earlier. Damaging waves from it arrived on the 8th. A LOW with a frontal system that extended southward and westward from about 145°W generated large waves which struck the Southern California coast on the 10th and 11th. Figure 4 is a photo of large breakers plunging over the sea wall at Redondo Beach later in the week, when new storms sent waves to the battered coastal area.

Compounding the damage from large surf were very high tides of about 7 ft during the period. Tidal heights of this magnitude will only be exceeded once in the area during 1978. Average and maximum reported surf heights at several beaches were 5 to 10 ft and 8 to 15 ft, respectively, on most days between the 8th and 23d.

Several other storms during late fall through the spring months brought damaging waves to the usually serene Southern California beaches. Surges occurred in late October, early November, late December, early February, and early March. The latter three episodes were associated primarily with extreme phenomena highlighted elsewhere in this report. The big waves that preceded and followed the January surge contributed heavily to wave damage for the season by pounding beaches at frequent intervals. However, the unusually high tides during much of the January wave episode made it the most severe of the season.

Lifeguards at Zuma Beach near Malibu believe it was the most damaging wave season in about a decade. Nearly 80 ft of beach was lost at Zuma by early March. By late May only about 20 ft had built back as the littoral transport flow began its seasonal reverse.

A few lives were lost due to the large waves, primarily careless fishermen or spectators who ventured too close to the pounding surf.

Property damage was extensive from Santa Barbara County southward to San Diego. Several dozen expensive homes and other structures were damaged. A few more were lost completely. Portions of the Coast Highway and a bicycle path were washed away. The damage could have been much greater, but timely National Weather Service advisories and strenuous cooperative efforts by residents, students, the Army, and others in sandbagging operations helped reduce the effects of the big waves.

RAIN AND WINDSTORM OF FEBRUARY 9 AND 10

A devastating storm brought death and destruction to Southern California coastal and mountain areas on the night of February 9. Extreme short-duration rainfall, falling on ground saturated by previous storms, triggered a major flash flood in the small mountain community of Hidden Springs. Mudslides also occurred in several heavily populated areas. Thunderstorms with winds in the 50- to 100-kn range caused extensive damage to structures and boats in several coastal communities.

Figure 5 shows the visual satellite picture of the eastern Pacific at 2315 on February 9. At that time, the storm center of 1000 mb was poised off the central California coast. An intense cold front extended southwestward to the tropical Pacific. Further deepening and intensification occurred as the storm slammed into

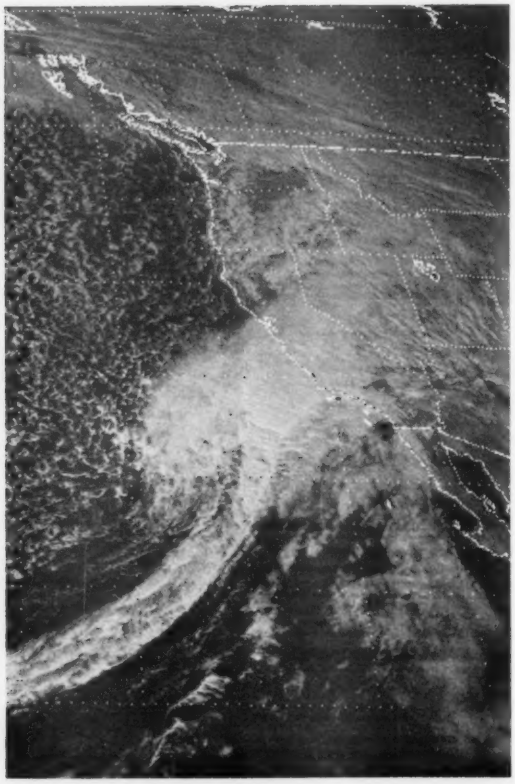


Figure 5.--A killer storm poised off the California coast on the afternoon of February 10.

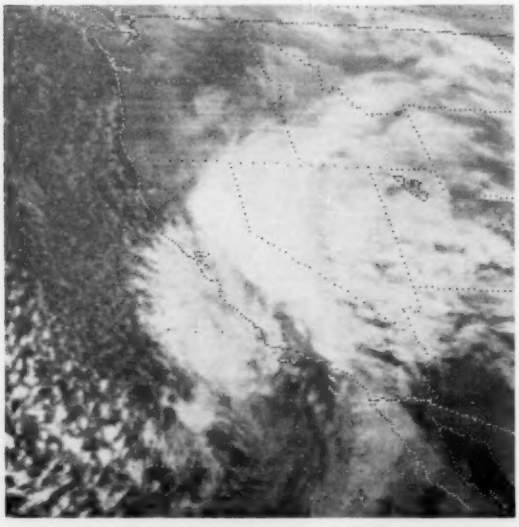
California during the next 12 hr. By 1200 on the 10th a double LOW had developed with a 990-mb center over western Nevada and a 993-mb center near Point Arguello. The double structure is apparent in the 0915 infrared imagery (fig. 6).

The flash flood struck Hidden Springs at about 1000 on the 10th. Ten people died as a 20-ft-high wall of water, mud, and debris destroyed nearly the entire community. Hidden Springs is located in a narrow canyon along Mill Creek at an elevation of approximately 2,500 ft. Figure 7 is a photo of some of the damage that occurred to the small San Gabriel Mountains resort town just north of Los Angeles.

Rainfall associated with this storm was as much as 13 in in 24 hr (Crystal Lake). Short-duration amounts at recording gages near Hidden Springs were very heavy between 0900 and 1000, and .48 in fell in 5 min at La Crescenta, about 10 mi southwest of Hidden Springs. Some other heavy amounts and durations occurred at Big Tunjunga Dam, about 4.5 mi downstream from the flash flood area:

.4 in - 5 min
1.1 in - 30 min
1.6 in - 60 min
3.0 in - 3 hr
3.9 in - 6 hr
6.2 in - 12 hr

In addition to the flood at Hidden Springs, mud and rock slides, road washouts, and downed power facilities were common throughout Southern California during this storm--one of the worst ever to strike the area. Some communities were isolated and automobile travelers were stranded for days. Power outages of several hours affected hundreds of thousands of people. Thirteen Southern Californians were killed as a direct result of the storm.



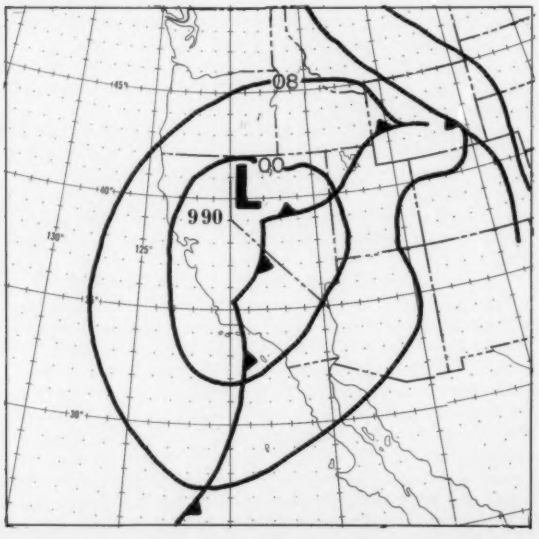



Figure 6.--Infrared imagery of double-low structure at time of Hidden Springs killer flash flood and vicious squall line winds in Los Angeles area. The corresponding 1200 chart of the 10th is shown on the right.

Figure 7.--Flash flood destruction at Hidden Springs. Photo by Charles Conway.

Raging flood waters destroyed the road leading to Pocoima Dam in the San Fernando Valley (fig. 8). Property damage from this storm is estimated to exceed $75 million in Southern California, including Kern County.

The squall line which accompanied the storm did extensive damage to boats and marine facilities in Los Angeles and Orange Counties. This intense line

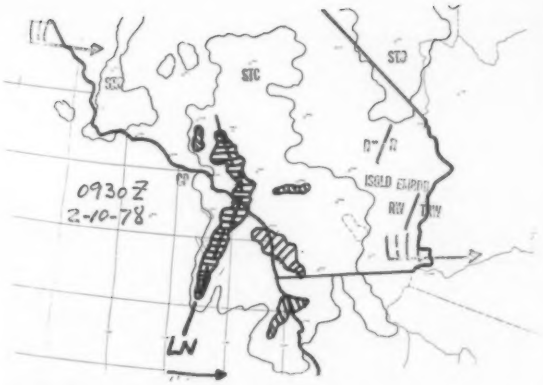



Figure 9.--Radar view of squall line raging through Los Angeles and Orange Counties during the early morning hours of February 10.

of raging hurricane-force winds is just passing over the Los Angeles area in the 0915 satellite view in figure 6. A radar depiction of the precipitation associated with the squall line at 0930 is shown in figure 9. Hundreds of boats were damaged or destroyed by the combination of wind, waves, and water damage. Boats were torn loose from their moorings and slammed onto rocks and into each other. Figure 10 shows sail-

Figure 8.--Bridge destroyed by flood waters near Pacoima Dam. Valley News Photo.

Figure 10.--Damaged sailboats in Los Angeles Harbor. San Pedro News Pilot Photo.

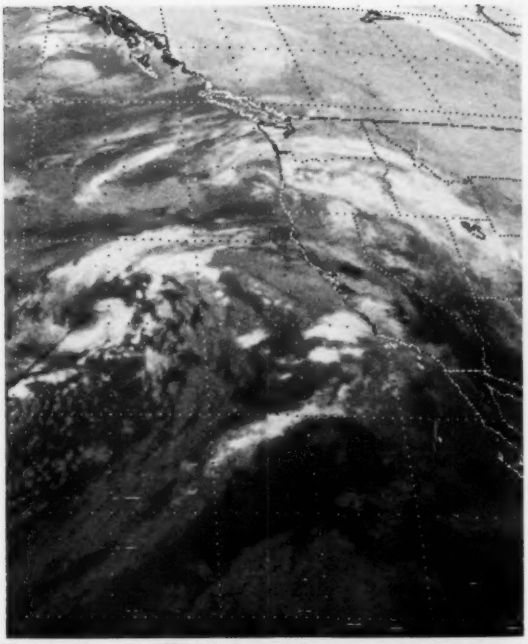


Figure 11.--Satellite infrared imagery of weak storm off the California coast on the morning of March 3. Storm intensified as it moved onshore.

boats which were thrown onto rocks in Los Angeles Harbor. Commercial shipping activities were severely curtailed by the storm. Los Angeles Harbor was closed for 10 hr because of the raging storm and debris-clogged waterways.

## PERSISTENT STORM PERIOD OF FEBRUARY 28 - MARCH 6

Heavy rainfall returned to Southern California for 7 consecutive days beginning on February 28. During this period, Los Angeles Civic Center recorded 8.5 in of rain. Camp Hi Hill in the San Gabriel Mountains, just north of Los Angeles, received 24.46 in. In terms of lives lost and property damage, this was the worst storm period of the 1977-78 season. Mudslides and flooding occurred in most foothill and mountain areas of Southern California. Large waves again pounded the beaches.

The week of heavy rain reached a peak during the morning of the 4th, when torrential rains sent streams over their banks and washed away saturated hillsides. The antecedent rainfall beginning on February 28 set the stage for the disasters that struck on the morning of March 4. The development of the storm of March 4 can be seen in detail in figures 11, 12, and 13. Infrared imagery for March 3 at 1745 indicated an innocuous LOW and frontal system off the California coast. At this time the front was quite weak, with only a few patches of cold-top clouds (bright areas). Twelve hours later at 0545 on March 4, infrared imagery (fig. 12) showed marked intensification of the frontal band as the LOW accelerated eastward and developed strong convection on the front between 36°N and the

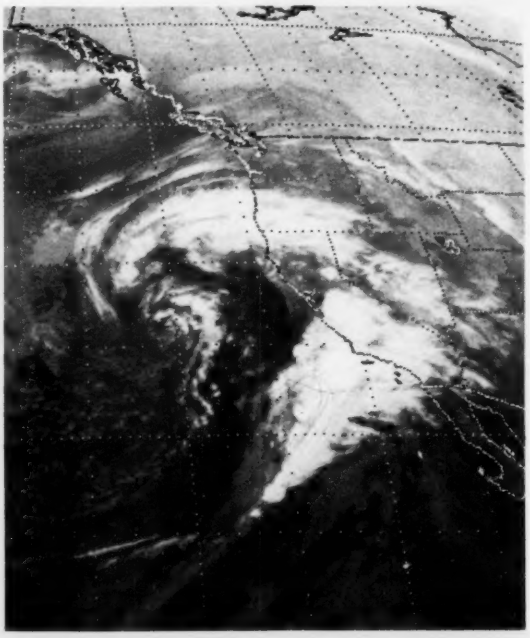


Figure 12.--Marked increase of cold cloud tops on infrared satellite photo graphically depicts 12-hr storm intensification. Compare with figure 11.

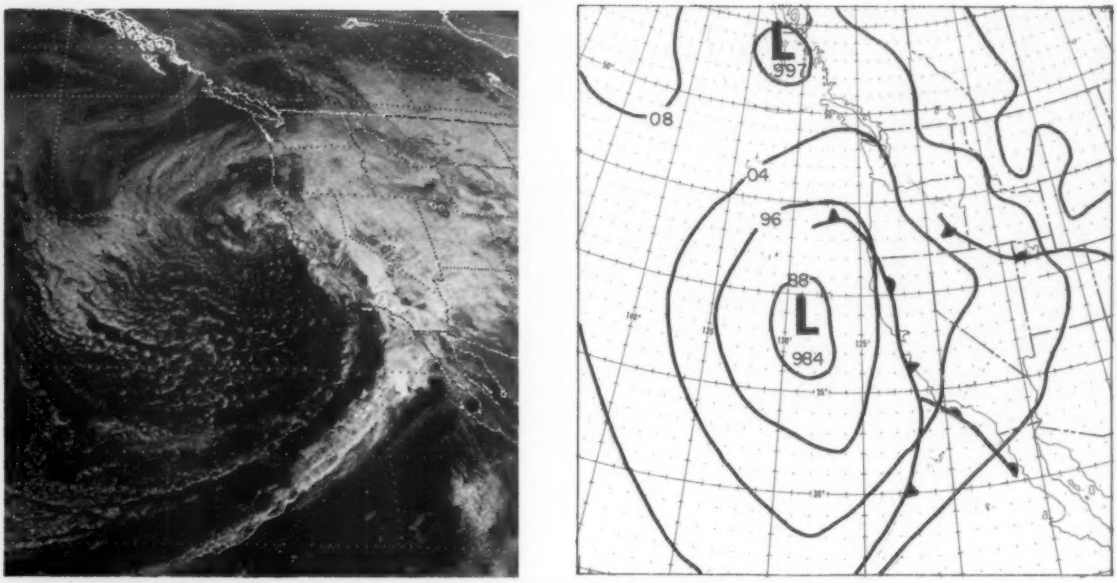



Figure 13.--Visual satellite photo of front and the surface synoptic situation which brought heavy rain, floods, and mudslides to large areas of central and southern California on the morning of March 4.

California-Nevada border. The strongest portion of the front passed over the Los Angeles area on the 4th at 1815 (fig. 13).

In Southern California 18 persons were killed directly by the storms on the 3d and 4th. More than 300 homes were damaged by slides and flooding. About half of them were severely damaged or completely destroyed. Figure 14 was an all-too-common scene in Southern California on the 4th. Stream flooding in Ventura and Santa Barbara Counties was the worst since 1969. Rock and mudslides continued into May, as weakened hillsides gave way under showery or even sunny skies.

Tijuana and Ensenada in northern Baja California suffered extensive damage during this storm period. At least 20 persons were killed as flood waters and mud rushed through heavily populated areas. Tens of millions of dollars in property damage jarred the economy of Baja California.

Large waves struck the coastline communities of Southern California again during early March. Waves generated by the series of storms brought 5- to 10-ft breakers and renewed damage to the already battered beaches and beach structures. Again, large-scale sandbagging operations were necessary to protect property at the edge of the sea. Property damage in Southern California for this storm period has been estimated at over $100 million.

SUMMARY AND SEASONAL RAINFALL STATISTICS

Estimates of lives lost and property damage from the series of destructive storms that struck Southern California during the winter of 1977-78 are as follows:

Deaths directly attributable to the storms - 35

Property damage - $200 to 250 million (about one-third of which was damage to agriculture)

Figure 14.--Mudslides destroyed this house (background) in San Fernando Valley on the morning of March 4. The house in the foreground was later condemned. Photo by Marcia Finke.

Figure 15.--California seasonal precipitation, October 1, 1977, to April 30, 1978. California Cooperative Snow Surveys Map.

During the four storm periods highlighted in this article, the National Weather Service Forecast Office in Los Angeles issued 66 special watches, warnings, advisories, and statements to the public and concerned agencies.

Nearly all southern and central California counties were declared Federal Disaster Areas as a result of the 1977-78 winter storms.

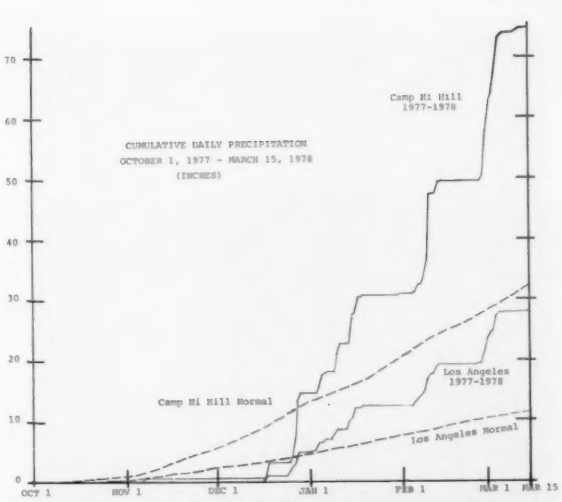



Figure 16.--Cumulative daily precipitation and normals for Los Angeles and Camp Hi Hill.

On the brighter side, precipitation from the storms ended the severe drought which had plagued California for the past 2 yr. Twice or more of normal precipitation fell over much of the southern and central portions of the State between October 1, 1977, and April 30, 1978 (fig. 15).

Los Angeles (coastal plain station) and Camp Hi Hill (mountain station, elevation 4,250 ft) seasonal cumulative daily precipitation and normals are plotted in figure 16. The graphs extend through March 15, 1978. Subsequent rainfall brought the season totals to among the highest on record. Los Angeles had the third highest seasonal total since records began in 1877 and the highest amount of this century.

REFERENCE

Gouze, S.C., and M.C. Richmond, 1978, The Meteorological Study of the December 1977 Wind Storm Along the Number 1 and 2 Midway-Vincent-500 kv Transmission Line Route on the North Slope of the San Emigdio Mountains, Meteorology Research Inc. Technical Report, Altadena, Calif., 21 pp.

THE MARINERS WEATHER LOG WELCOMES ARTICLES AND LETTERS FROM MARINERS RELATING TO METEOROLOGY AND OCEANOGRAPHY, INCLUDING THEIR EFFECTS ON SHIP OPERATIONS.

Mariners Weather Log

# RAPIDLY DEVELOPING EASTERN NORTH PACIFIC TROPICAL CYCLONES

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During the 4-yr period 1973 to 1976, the Synoptic Analysis Section of the National Environmental Satellite Service monitored 62 tropical cyclones in the eastern North Pacific Ocean. Using the Dvorak Classification System (Dvorak, 1975) operationally, satellite meteorologists tracked and analyzed the life cycle of these eastern Pacific tropical cyclones. Twelve of the cyclones underwent rapid development. The initial points of rapid development were within a rather small geographical area. The identification of this initial rapid development area and its possible application to analysis and forecasting is described in this article. An example of a rapidly developing cyclone is included.

Individual cyclones were analyzed operationally using visible satellite imagery. The effect of diurnal variations in the cloud patterns was minimized by observing the cyclone at the same time each day. Post-analysis "best fit" smoothing of position and intensity curves was used to eliminate most of the operational errors due to gridding problems, variable analysis personnel, deadlines, lack of timely data, and so on.

Typical development and rapid development of tropical cyclones were defined by Dvorak as being an increase of one T number in 24 hr and one and one half T numbers in 24 hr, respectively (fig. 17). For the purpose of this study the term rapid development was limited to cyclones with an increase of at least three T numbers in 48 hr. Also included are cyclones that moved over land after 24 hr of rapid development. This redefined concept of rapid development does two things: (1) eliminates cyclones with short-term rapid growth rates (12 to 24 hr) that otherwise would be considered a typical development; and (2) minimizes analysis bias. An example of rapid development would be as follows: a cyclone classified as a T2 (30 kn) on day 1, T3.5 (55 kn) on day 2, and T5 (90 kn) on day 3.

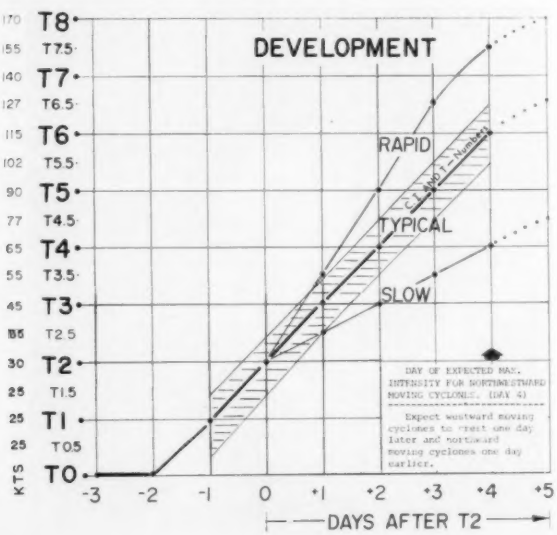


Figure 17.--Tropical-cyclone development curves (from Dvorak, 1975).

When the tracks of these rapidly developing cyclones were plotted, the portion of their track where rapid development occurred fell within a small area south of Mexico. This has been termed the Total Rapid Development Area (fig. 18). Observing the initial points of rapid development revealed a very small concentrated area with corresponding intensities of approximately T2 (30 kn). This has been termed the Initial Rapid Development Area (fig. 18). For comparison, all 62 eastern Pacific tropical cyclones were plotted at approximately the T2 stage. Seven cyclones, which were not developing rapidly, were observed within the Initial Rapid Development Area, and two of these cyclones developed in early and late months (May and November) when environmental conditions probably were not favorable for rapid development. Note that the 12 rapidly developing cyclones occurred between June and early October.

It is not the intent of this paper to completely explain the reasons for the concentration of rapidly developing cyclones; however, several factors may have contributed significantly. Because of persistent warm sea-surface temperature patterns and climatologically favorable atmospheric conditions, this area can be viewed as a natural "operational laboratory." This might lead to a fixed geographical location for rapidly developing cyclones. Even though the 4 yr of data indicate a surprisingly small area of initial rapid development, future data might possibly expand the size of this area.

Of the 12 rapidly developing cyclones, hurricane Diana (July 1976) is a prominent example. In 3 days this cyclone developed from a poorly organized tropical disturbance with maximum winds of 25 kn (T1) to a well-developed, mature hurricane with winds over 100 kn (T5.5)--a tremendous increase in intensity in 72 hr.

On July 14, 1976, a weak tropical system began developing near 10°N, 96°W (fig. 19). The GOES-I satellite picture revealed a system center defined by broadly curving bands of convection (T1). The center was developing on the southern end of a large area of convection extending northeastward into Central America, probably associated with a westward-moving tropical wave. On the 15th (fig. 20) Diana

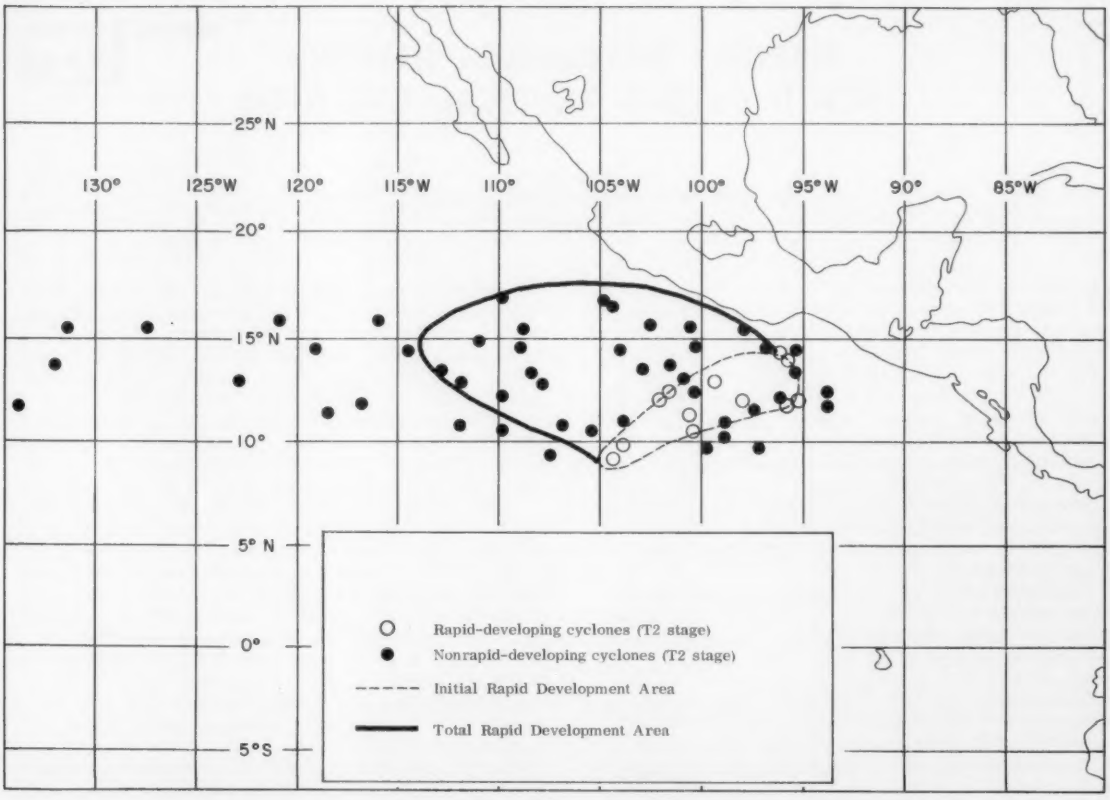


Figure 18.--Area of development of eastern North Pacific tropical cyclones, 1973-76.

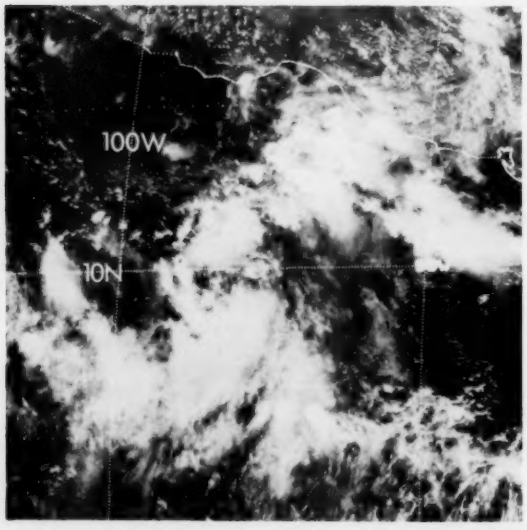


Figure 19.--Depression Diana at 1700 on July 14, 1976 (T1 stage).

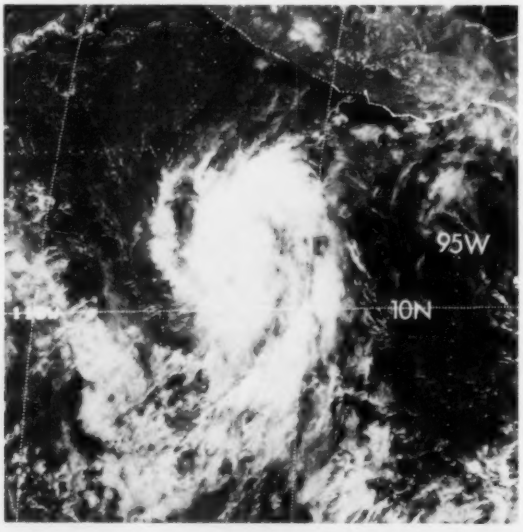


Figure 20.--Tropical storm Diana at 1700 July 15, 1976 (T2.5 stage).

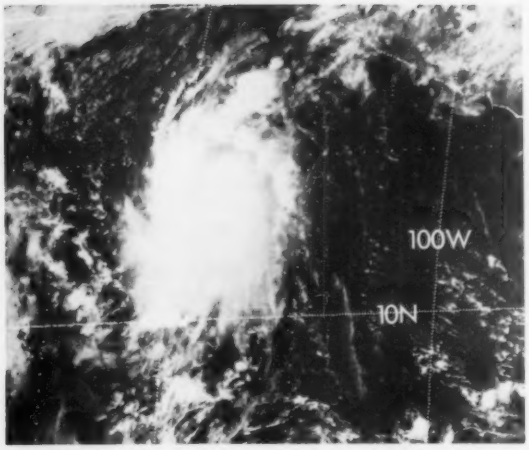


Figure 21.--Hurricane Diana at 1800 July 16, 1976 (T4 stage).

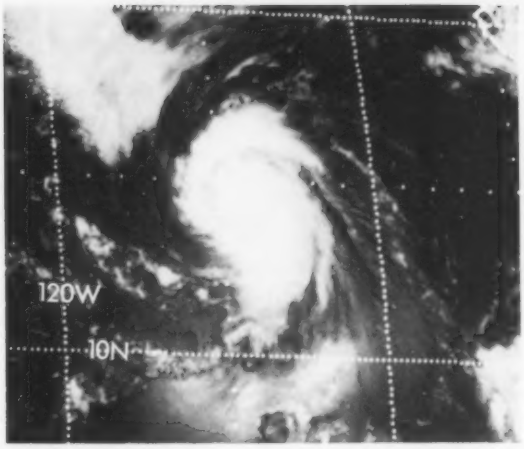


Figure 22.--Hurricane Diana at 1745 July 17, 1976 (T5.5 stage).

was a minimal tropical storm with maximum winds approximately 35 kn (T2.5). Large structural changes had occurred within the system. A central overcast had developed with quasi-circular bands encircling it. A marked clearing could be observed around the periphery of the cyclone for several hundred miles. This clearing and the deep-layered convective bands in advance of the center are often indicators of future development.

Diana continued to develop rapidly on the 16th (fig. 21). The large central overcast completely encircled by banding features indicates winds approaching hurricane intensity (T4). On the final day of rapid development, the 17th (fig. 22), Diana's winds were near 100 kn (T5.5 as viewed from SMS-II satellite). The small distinct eye embedded within the overcast was almost completely encircled with outer bands.

Two satellite-viewed predictors of slowing development were present on the 17th. The first was a large tongue of stratocumulus lying in the projected track of the center. The second is revealed by examining sea-surface temperatures in the area around the center. The temperatures were only 25° to 26°C, with colder temperatures along the projected track of Diana. These two predictors alert forecasters to a slowing in development over the next 24 hr.

As mentioned earlier, from the total number of eastern Pacific cyclones over the past 4 yr, 12 developed rapidly--thus giving a 20 percent probability of rapid development for any one of the 62 cyclones. This probability is increased to 65 percent in the dependent data sample which deals with those disturbances that were developing within the Initial Rapid Development Area at the T2 stage.

Recognizing rapid development is of paramount importance in data-sparse regions where tropical-cyclone intensity forecasting is extremely difficult. Therefore, some probable forecast decisions for rapid development in the eastern Pacific have been devised:

1. Is the tropical system within the Initial Rapid Development Area at the proper stage of development ($\geq$ T2)?
2. Are favorable sea-surface temperatures ($\geq$ 27°C) present and along the projected track?
3. Do any favorable satellite-observed predictors exist?

The first decision can be evaluated objectively; and by examining the second and third decisions, forecast probabilities should increase beyond 65 percent. Access to accurate sea-surface temperature charts and the ability to predict the future path of the cyclone are critical to the second decision. Although the third decision is somewhat subjective, there are several favorable satellite-indicated predictors that should be considered at the T2 stage: well-defined, cloud-system center in this early stage; strong banding features in advance of the system center; tight quasi-circular banding; and symmetric cloud patterns with good outflow. If any of these features are analyzed in conjunction with positive responses to decisions 1 and 2, then forecasters may be able to improve the probability for predicting the occurrence of rapid development.

Besides the forecast applications of this study, satellite meteorologists will likely benefit as well. As previously mentioned, operational satellite analysis can have numerous pitfalls. Being as objective as possible analysts are sometimes confronted with subjective decisions that can result in errors. In a recent paper (Sheets, 1976) a comparative study was done between research aircraft and satellite-determined storm intensities. One of the important conclusions from this paper revealed a problem with rapidly changing cyclones where the satellite classifications lagged behind the observed changes. The most probable reason for this lag with developing cyclones is a conservative bias among most satellite analysts. To accurately classify rapidly developing cyclones in the eastern Pacific Ocean, satellite analysts, utilizing the three forecast decisions operationally, should improve their skills and objectivity.

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Mariners Weather Log

# ELEVEN YEAR CHRONICLE OF ONE OF THE WORLD'S MOST GIGANTIC ICEBERGS

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Washington, D.C.

Although there are published reports of satellite tracking of icebergs for a few months to a few years (Sissala, 1969; Swithinbank, 1969), the most comprehensive attempt to date is probably that of Swithinbank et al. (1977). They present the drift tracks of 14 tabular bergs ranging upward in size from 5 by 5 km (nearly all exceeded 30 by 20 km) for periods of 1 to 9 yr. Next to the largest of these, and the one with the longest documented history to date, is the subject of this article.

Monitoring of sea-ice conditions in the polar areas of both hemispheres (McClain and Baliles, 1971) has been rendered routine since the inauguration of the TIROS and NIMBUS weather satellites in the early 60's,

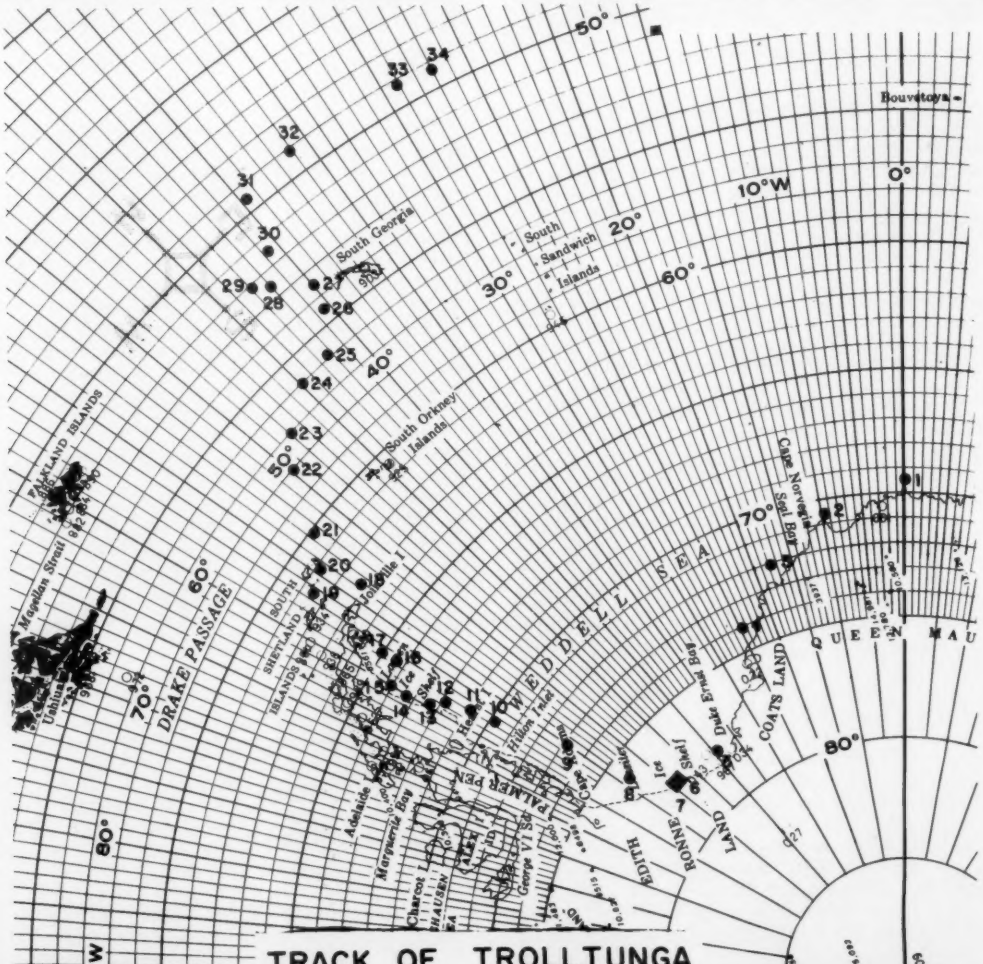


Figure 23.--Selected satellite-determined positions along the track of the Trolltunga giant iceberg during 1967 through 1978. The dates corresponding to the numbered positions are found in table 1.

Table 1.--Chronology of Trolltunga's track shown in figure 23

| NO. | DATE | NO | DATE |
|---|---|---|---|
| 1 | 3- 8-67 | 18 | 5-24-77 |
| 2 | 10-11-67 | 19 | 7-24-77 |
| 3 | 11- 7-67 | 20 | 9-23-77 |
| 4 | 1-10-68 | 21 | 11- 3-77 |
| 5 | 1-15-69 | 22 | 12-10-77 |
| 6 | 1-15-70 | 23 | 12-25-77 |
| 7 | 1-26-75 | 24 | 1-13-78 |
| 8 | 3-18-75 | 25 | 1-21-78 |
| 9 | 5-15-75 | 26 | 2- 3-78 |
| 10 | 6-30-75 | 27 | 3- 2-78 |
| 11 | 8-15-75 | 28 | 3-10-78 |
| 12 | 11- 7-75 | 29 | 3-19-78 |
| 13 | 1-30-76 | 30 | 3-27-78 |
| 14 | 3-10-76 | 31 | 4-21-78 |
| 15 | 5-26-76 | 32 | 5-5-78 |
| 16 | 1-31-77 | 33 | 5-24-78 |
| 17 | 3- 9-77 | 34 | 5-29-78 |

followed by improved operational environmental satellites in the early 70's. Early satellite observations were confined to the period from late spring through early autumn because of lack of solar illumination the remainder of the year, but more recent spacecraft have been equipped with infrared radiometers, which largely remove this constraint (McClain, 1974a). Measurements from modern spacecraft are also of higher resolution, allowing more detailed interpretation of sea-ice conditions (McClain, 1974b; Campbell et al., 1975). Cloud obscuration continues to be the most serious problem for ice montioring by satellite, although even this limitation has been lifted for large-scale ice mapping through use of microwave sensors (Zwally and Gloersen, 1977).

Most of the sea ice appearing in the 1- or 4-km resolution images from NOAA's polar-orbiting operational satellites is pack ice fields or shorefast ice. Although often very widespread (hundreds of kilometers), these types of ice are generally only a few meters thick. Icebergs, on the other hand, which derive (i.e., calve) from glaciers, ice tongues, or ice shelves, are generally rather small in horizontal extent (tens to hundreds of meters) but are much thicker than pack ice, often extending 50 to 100 m above the waterline and up to five times that below (Thoren, 1969). Although large tabular icebergs, or ice islands (a few tens of kilometers on a side), are known to originate from ice shelves in northern Ellesmere Island and northern Greenland, truly gigantic tabular bergs intermittently calve from the Ross, Filchner, and Shackleton ice shelves in Antarctica. Lengths of over 10 km are not unusual, and a berg over 140 km in length was reported by a whaler in 1927 near Clarence Island (61°S, 54°W). These Antarctic tabular icebergs extend from 30 to 40 m above the ocean surface to over 300 m below (Fairbridge, 1976).

A comparison of Antarctic charts before and after 1967 (American Geographical Society, 1965 and 1970) reveals that a large portion of the Trolltunga ice tongue at 69.5°S, 1°W, is missing from the more recent charts. This ice tongue is clearly visible in ESSA satellite images taken in March 1967 and earlier. In satellite data of October 1967 and later most of the Trolltunga tongue is gone, but a large berg of the same general size and shape as the missing tongue is visible drifting southwestward along the coast (Swithinbank et al., 1977). This gigantic iceberg, which is here called Trolltunga after its origin, became grounded near 77°S, 48°W (fig. 23 and table 1) just off the Filchner ice shelf in 1969, where it was to remain for some 5 yr. An excellent Landsat (NASA, 1976) image of the berg was obtained on December 11, 1973 (fig. 24). Because of the high spatial resolution (viz., 80 m) and orthogonal view provided, an accurate measurement of the berg's length and width can be made: 103 by 60 km. To give the reader some feeling for the enormity of this piece of ice, its planimetered area is 4,650 $km^2$ (1,794 $mi^2$), which is comparable to nine-tenths of the area of the state of Deleware, 2,057 $mi^2$. Assuming an average total thickness of 250 m, the volume of ice is about 1,162.5 $km^3$ (278.5 $mi^3$); and assuming a density of 0.84 (Swithinbank, 1955), the mass would be about 976.5 by $10^9$ metric tons (1,076.4 by $10^9$ short tons). Melted, this volume of ice would yield 976.5 by $10^{12}$ l (258 by $10^{12}$ gal), which is nine times the total yearly water use in the United States in 1965 (viz., 28.47 by $10^{12}$ gal) (Todd, 1970).

Trolltunga resumed its travel in February 1975, still embedded in the perennial ice pack of the Weddell Sea, and reached a point near the northeast tip of the Antarctic Peninsula about 2 yr later (Position No. 16, fig. 23 and table 1). Here, another Landsat view was obtained (fig. 25), and a second measurement was made of the maximum length and width of the berg: 92 by 50 km. From comparison of the shape of the iceberg in the two images, it is quite evident that there has been a substantial loss of mass from at least two parts of one side and from one end. That this took place by the calving of several major fragments from the main berg was confirmed by several NOAA-5 VHRR images obtained in October and November 1976.

By March 1977 Trolltunga was drifting free of the pack ice and heading generally northward. The iceberg drifted around Joinville Island, just off the tip of the peninsula, first toward the northwest, and then becoming quasi-stationary for about a month just to the south of the passage between King George Island and Elephant Island in the South Shetlands. It then accelerated northeastward to pass just east of the Elephant and Clarence Islands into the open South Atlantic Ocean (Position Nos. 18 to 22, fig. 23 and table 1).

By March 1978 Trolltunga had reached a point just west of South Georgia Island at latitude 54°S (fig. 26). An estimate of its length is aided by the proximity to the island (both the berg and the island have comparable orientation; and, therefore, similar geometric

Figure 24.--Landsat-1 MSS-5 image of the Trolltunga giant iceberg on December 11, 1973, when it was grounded near 77°S, 48°W (Position Nos. 6 and 7 on figure 23). Mostly consolidated pack ice appears at the upper right; a portion of the Filchner Ice Shelf is seen at lower right; and clouds cover the upper left half of the image.

distortion in the VHRR image) and would indicate that the longest dimension of the berg had probably decreased only a little from that measured in January 1977.

The iceberg's generally northeastward track became essentially due east after April 1978. Lack of solar illumination at time of passage of NOAA-5 and scheduling constraints prevented further coverage by means of the VHRR after March, but fortunately the iceberg had moved to within the outermost limits of coverage by GOES-2, NOAA's operational geostationary satellite (Hussey, 1974) at longitude 75°W. Using ground equipment known as a sectorizer, 1-km resolution, visible-band coverage of the area surrounding the berg was scheduled daily near noon local time.

Trolltunga has been identified (fig. 27) under cloud-free and partially clouded conditions on the average of 2 or 3 times a week from April through July. On several occasions the iceberg has been located nearly every day for periods of 2 weeks or more. During one such period in June the berg apparently made a loop around a seamount, an undersea mountain.

The GOES-2 views of Trolltunga are so oblique that extreme foreshortening and consequent distortion in shape are apparent in the images (compare the shapes of the berg in figs. 25, 26, and 27), making accurate measurements of its size difficult. By using an optical device that enables variable magnification and one-dimensional stretching of the image and its emplanted

Table 2.--Horizontal dimensions of the Trolltunga iceberg

| Date | Length (km) | Width (km) | Satellite/Sensor |
|---|---|---|---|
| 12/11/73 | 103 | 60 | Landsat-1/MSS |
| 1/31/77 | 92 | 50 | Landsat-1/MSS |
| 3/2/78 | 94 | 45 | NOAA-5/VHRR |
| 5/5/78 | 71 | 31 | GOES-2/VISSR |
| 6/18/78 | 56 | 23 | GOES-2/VISSR* |

*Average of 6/14, 6/18, and 6/19

grid, it is possible to remove most of the distortion and remap the iceberg onto an equal-area projection. Several of the best Trolltunga images were analyzed in this way to yield the dimensions given in table 2. The Landsat measurements are accurate to 0.5 km and the NOAA-5 measurement to within 2 km, but the GOES-2 measurements are probably accurate to no better than 5 km. Even allowing for these errors, it seems evident from table 1 that a considerable reduction in horizontal area took place, especially from April to June 1978. Although Thoren (1969) states that "large bergs last approximately 2 weeks or more in 4°C water," this is of little help in predicting the lifetime of a gigantic tabular iceberg such as Trolltunga because the large Arctic bergs he refers to are so much smaller

Figure 25.--Landsat-1 MSS-5 image of the Trolltunga giant iceberg on January 21, 1977, near 65°S, 57°W (Position No. 17). The berg is surrounded by unconsolidated pack ice; a portion of the Antarctic Peninsula is at the left.

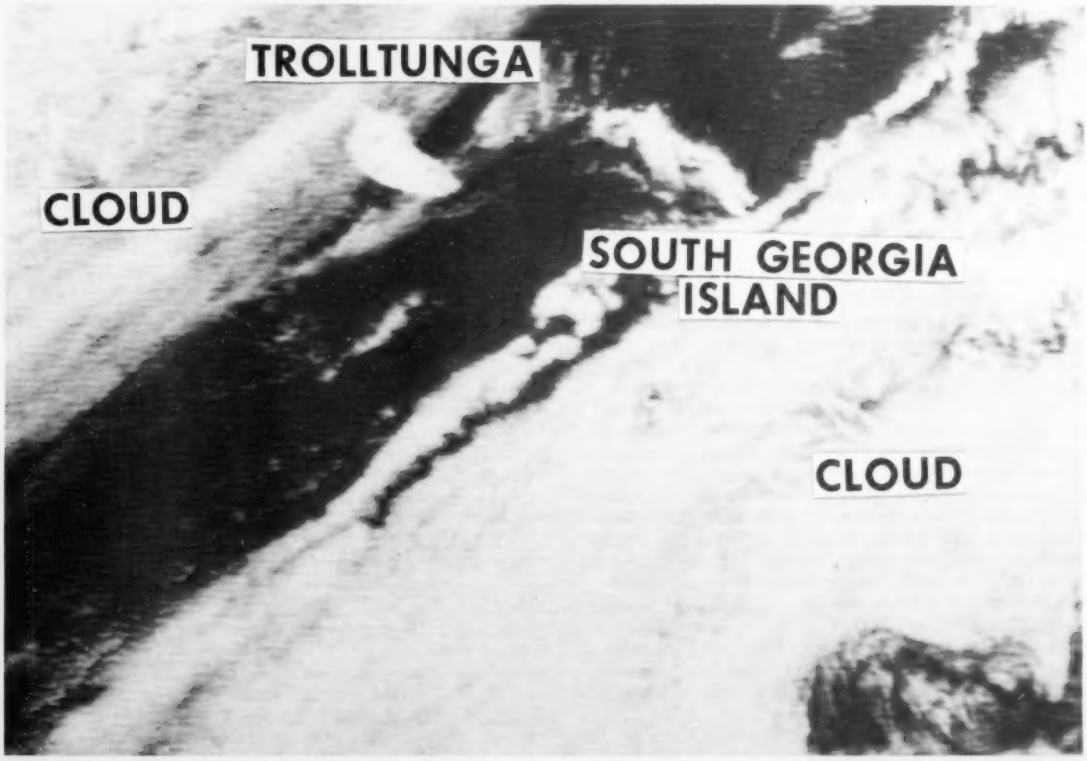


Figure 26.--NOAA-5 VHRR-VIS (Schwalb, 1972) image of the Trolltunga berg on March 2, 1978, as it drifted west of South Georgia Island near 54°S, 40°W (Position No. 27).

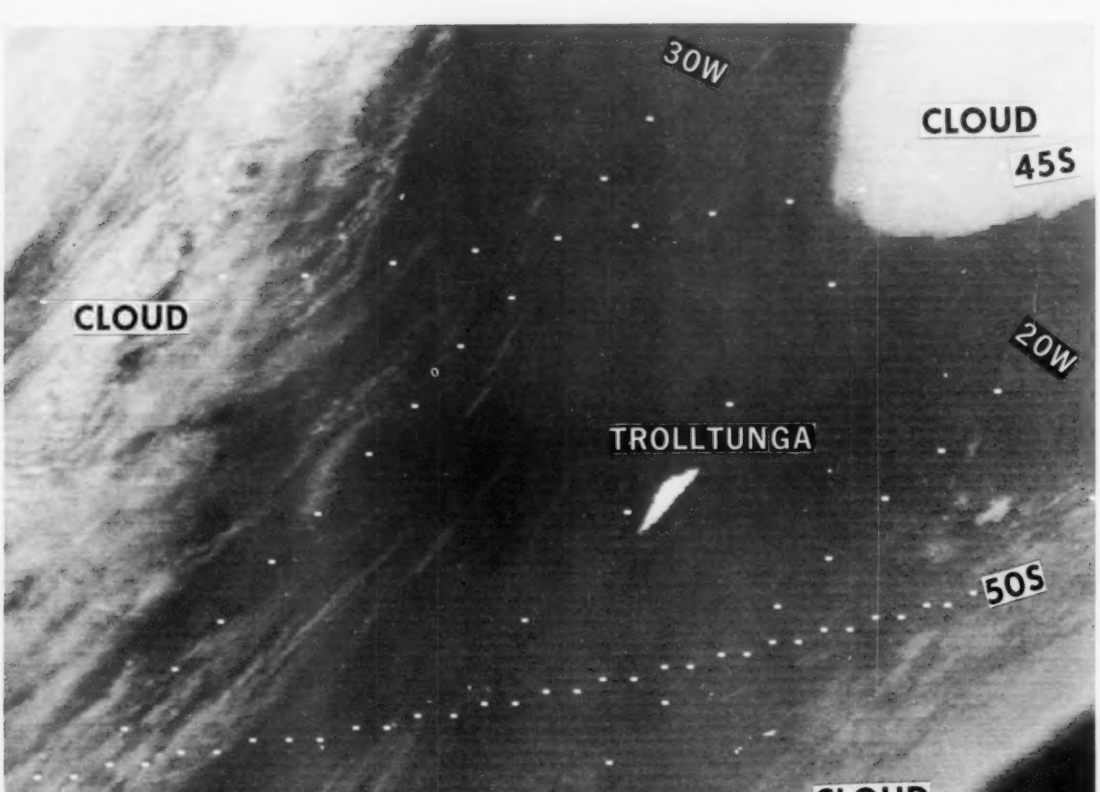


Figure 27.--GOES-2 VISSR-VIS image of the Trolltunga berg as it drifted eastward near 48°S, 25°W.

than Trolltunga.

In their critical appraisal of icebergs as a freshwater source, Weeks and Campbell (1973) attempted to assess the in-transit melting of various size bergs towed along certain routes. The transit time for their longest route (Ross Sea to Atacama Desert, 9 by $10^3$ km), their largest iceberg and their smallest towing force was about 260 days, indicating an average rate of travel of about 35 km/day. Trolltunga, of course, has been merely drifting with the prevailing currents, and its average speed between positions No. 19 and 34 was between 9 and 10 km/day. In the calculations presented by Weeks and Campbell (1973) their sample iceberg (initial dimensions of 2.8 by 11.2 by 0.25 km = 7.84 $km^3$) decreased by 4 percent in width, 1 percent in length, and 25 percent in thickness for an overall volume reduction of 30 percent. Also interesting is that the results were not particularly sensitive to towing force (transit time) or to the horizontal dimensions of the iceberg if they were in excess of about 2.5 by 10 km.

Clearly the amount of melting is proportional to the ocean temperature an iceberg encounters along its drift or towed track and to the differential velocity between the ice and the water. In the candidate routes evaluated by Weeks and Campbell (1973) the sea temperatures at the northern end of the transits exceed 15°C, and temperatures during more than half of the transits are in excess of 5°C. Relative velocities ranged from 0.1 to 4.0 m/s. In the case of Trolltunga, its thermal environment has not been as conducive to melting, with sea temperatures probably no higher than about 4°C anywhere along its track and in the range of 0° to 2°C along most of it. Furthermore, the relative velocity between a free-drifting iceberg and the surrounding water is generally quite small.

The amount of melting calculated by Weeks and Campbell for their hypothetically towed icebergs should be a substantial overestimate of the amount to be expected in the case of Trolltunga, although it should be noted that these investigators did not include estimates of the amount of ice lost by calving of fragments from the main berg. According to table 2, the length and width of Trolltunga diminished by 40 and 49 percent, respectively, between March 1 and mid-June of this year. It appears highly improbable that this much loss in area could be attributed to melting; therefore, calving must be the responsible mechanism. As pointed

out earlier, a large part of the 10- to 20-percent loss in length and width between December 1973 and January 1977 took place by calving over a month or two in late 1976.

What are likely to be the final stages in the saga of this great tabular iceberg, given what has been observed to date and given knowledge of the general ocean currents that can influence its future drift? If we are even approximately correct in our assessment of its areal attrition rate, it should become so small (say less than 5 km across) as to be undetectible in GOES-2 images before October 1978, and undetectible in Landsat images (say less than 300 m across) before the end of 1978. At its past average speed of 9.5 km/day and tracking nearly due eastward, the remnants of Trolltunga could reach a position near 49°S, 12°W, by October 1, 1978, and near 50°S, 0°W, by December 31, 1978.

Future tracking of icebergs by satellite, particularly with the extremely high resolution (25 m) of an instrument such as the SAR (Synthetic Aperture Radar) on Seasat (U.S. Dept. of Commerce, 1977), which is not particularly hampered by clouds, should give scientists new information on ocean currents and on the mass lost from icebergs by calving. Both these factors, but particularly the latter, significantly affect the economic feasibility of using towed icebergs as a source of fresh water.

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WE OF NOAA ARE MAKING USE OF THIS SMALL AMOUNT OF SPACE TO EXTEND OUR THANKS TO ALL THE SHIPS' OFFICERS WHO ROUTINELY TAKE SHIPBOARD WEATHER OBSERVATIONS. TO US THESE EXCELLENT OBSERVATIONS ARE PRICELESS. WE CERTAINLY DO APPRECIATE RECEIVING THEM ON A REGULAR BASIS.

# Hints to the Observer

Robert G. Quayle
National Climatic Center, NOAA
Asheville, N.C.

## THE FGGE MARINE PROGRAM

FGGE (acronymically pronounced "figgy") stands for First GARP Global Experiment. GARP, in turn, is an acronym for the Global Atmospheric Research Program of the World Meteorological Organization.

Surface ship data are among those most critically needed for a successful FGGE. Ships' observations will provide the basic weather data over most of the surface of the globe. They will be used as "ground truth" (or more properly, "sea truth") for satellite measurements as well as input to sophisticated computer analysis and forecast programs.

The major goals of the project are:

- To obtain a better understanding of atmospheric motion for the development of more realistic models for extended range forecasting, general circulation studies, and climate.

- Assessment of the ultimate limit of predictability of weather systems.

- Development of more powerful methods for assimilation of meteorological observations and, in particular, for using nonsynoptic data as a basis for predicting the large-scale motion.

- Design of an optimum composite meteorological observing system for routine numerical weather prediction of the large-scale features of the general circulation.

Figure 28.--The many observing systems that will contribute data to the FGGE program.

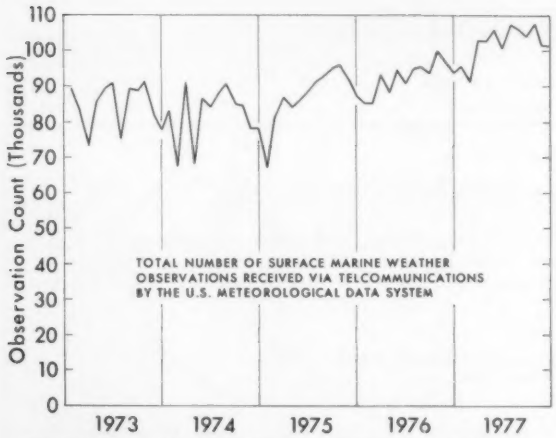


Figure 29.--Total number of surface marine observations received by telecommunications, 1973-77.

The method to be used for accomplishing these goals will be observation of the global atmosphere and ocean in detail for a full year by means of coordinated international effort and subsequent analysis and research using the global data base. The many observing systems serving FGGE are graphically depicted in figure 28. Meteorological services all over the world began preparing in December 1977 to be ready for the FGGE operations in December 1978. The FGGE year ends November 1979.

In order to obtain a maximum amount of ship data, over 40 World Meteorological Organization member countries who operate Voluntary Observing Ships have agreed to make special efforts to expedite transmittal of an increased number of observations to the appropriate FGGE centers. Special procedures include:

1. Transmit weather observations on a regular basis.

2. Mail forms directly to the FGGE centers as soon as possible after the ship makes port. The U.S. Port Meteorological Officers will supply ships with envelopes and labels addressed to the National Climatic Center (NCC), Asheville, N.C., for this purpose.

3. NCC will process data as quickly as possible so that it can be incorporated into the total FGGE master data set.

4. Make extraordinary efforts to take and transmit observations during January through June 1979, which includes the FGGE Special Observing Periods.

Hopefully, the progressive increase in data (see fig. 29) can be accelerated in 1978-79. Data from the Tropics and Southern Hemisphere areas are sorely needed--particularly atmospheric pressure and sea-surface temperature.

The efforts expended on this experiment so far have been tremendous, but success depends upon the cooperation of each ship observer and radio operator in the Fleet. An entire year is a long time to ask for special consideration in taking and transmitting weather observations, but the end result of improved forecasts will certainly be worth it.

Future items of FGGE interest will be covered in Hints to the Observer.

## NEW PROCEDURES FOR MAILING SHIPS WEATHER OBSERVATIONS

The letter below outlines new procedures for mailing Ships' Weather Observations forms directly to the archival center instead of to the Port Meteorological Office. The change will expedite delivery of the observations and will give the PMOs more time for other duties.

National Weather Service
Silver Spring, Md. 20910

W521x2/RWS

Dear Captain:

We need your help. We're making a change in the way you mail your forms. The change will speed up delivery of the forms and give our Port Meteorological Officers more time to visit ship's observers like you and your officers.

Please start sending your completed SHIPS WEATHER OBSERVATIONS forms directly to our archival center at:

National Climatic Center/NOAA
Federal Building
Asheville, N.C. 28801

A supply of pre-addressed envelopes are enclosed for this purpose. Discard any old envelopes you now have that are addressed to a Port Meteorological Office.

Your PMO will still keep your ship supplied with observing materials and inspect observing equipment. The National Climatic Center will inform the PMO when records from your ship are received and, if you've indicated a need for supplies. This procedure will be followed until you receive the latest revision of the SHIPS WEATHER OBSERVATION forms. The new form will include postal cards for ordering supplies, address changes and requests for PMO service. While waiting for the new log, continue to use the order block on the back of the old form for ordering supplies. If you encounter any problems please let me or any Port Meteorological Officer know.

We wish to thank the ship's officers who routinely take and send shipboard weather observations. Regular observations are essential to good marine forecasts.

Sincerely,

Robert W. Schoner
Marine Program Leader

Enclosures

# Tips to the Radio Officer

Thomas H. Reppert
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## U.S. OFFSHORE MARINE WEATHER BROADCASTS

Figures 30 and 31 show the broadcast schedules, frequencies, times, and areas of coverage of U.S. Offshore marine weather broadcasts by radiotelegraph and radiotelephone. The maps are available from the Marine Weather Services Branch (W162), National Weather Service, NOAA, Silver Spring, Md. 20910.

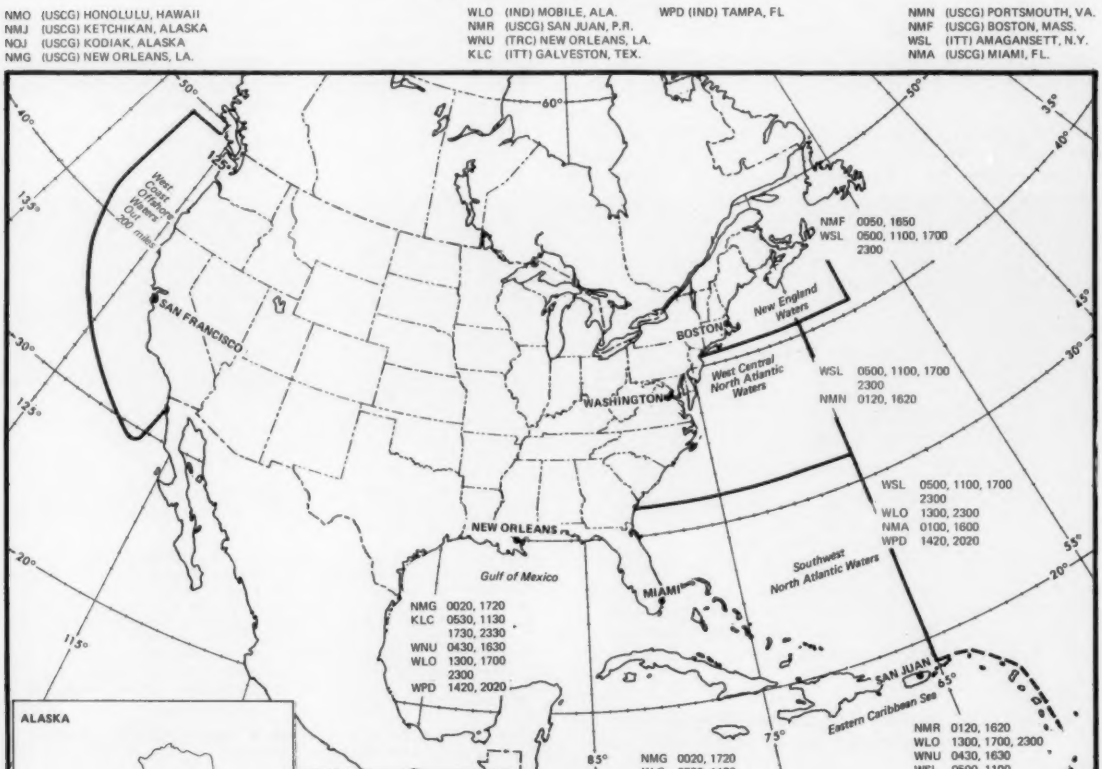
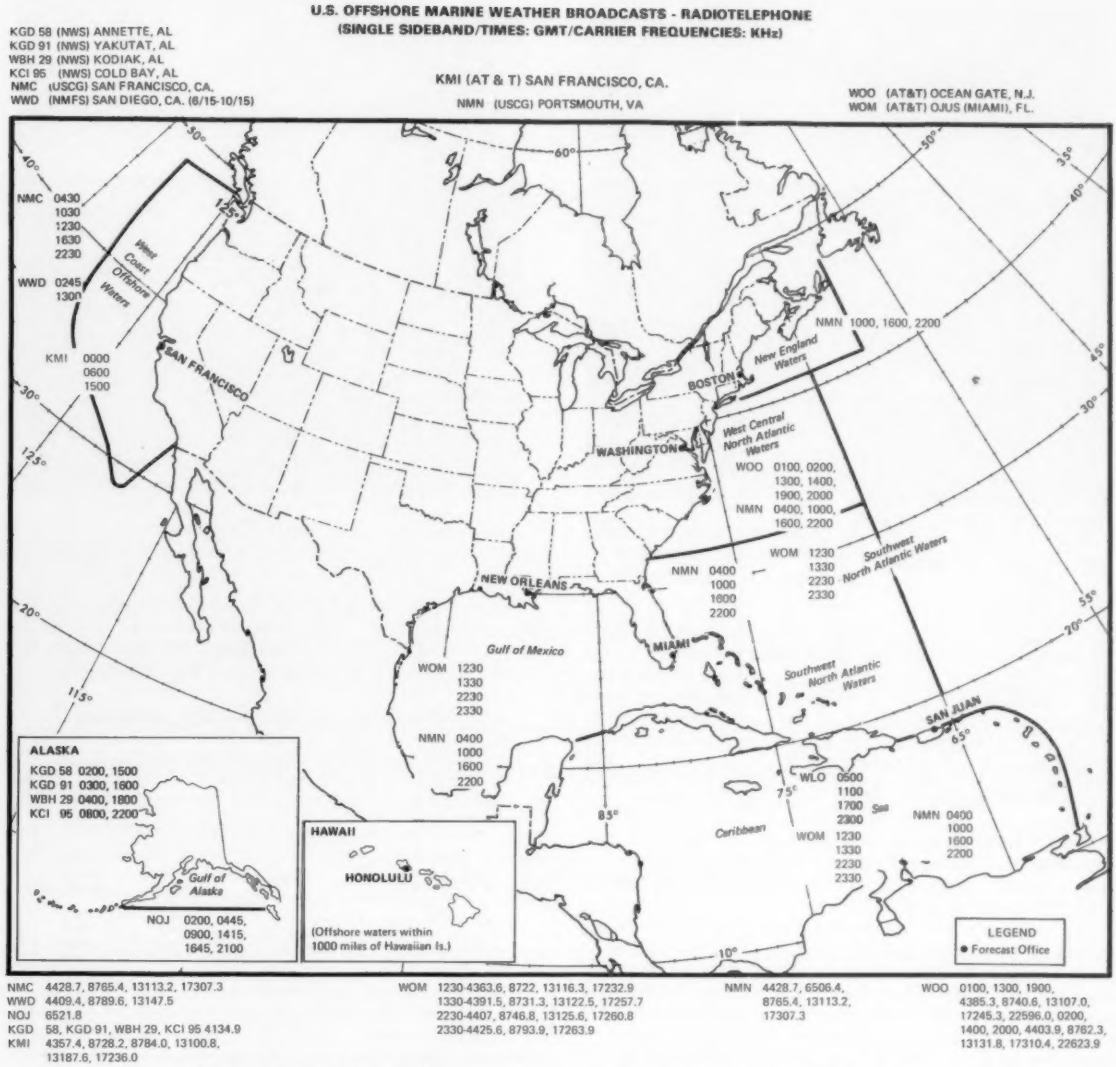



Figure 30.--U.S. offshore marine weather broadcasts - radiotelegraph.


U.S. OFFSHORE MARINE WEATHER BROADCASTS - RADIOTELEPHONE
(SINGLE SIDEBAND/TIMES: GMT/CARRIER FREQUENCIES: KHz)
KGD 58 (NWS) ANNETTE, AL
KGD 91 (NWS) YAKUTAT, AL
WBH 29 (NWS) KODIAK, AL
KCI 95 (NWS) COLD BAY, AL
NMC (USCG) SAN FRANCISCO, CA.
WWD (NMFS) SAN DIEGO, CA. (6/15-10/15)
KMI (AT & T) SAN FRANCISCO, CA.
NMN (USCG) PORTSMOUTH, VA
WOO (AT&T) OCEAN GATE, N.J.
WOM (AT&T) OJUS (MIAMI), FL.
NMC 0430 1030 1230 1630 2230
WWD 0245 1300
West Coast Offshore Waters
KMI 0000 0600 1500
SAN FRANCISCO
NMN 1000, 1600, 2200
New England Waters
BOSTON
WASHINGTON
West Central North Atlantic Waters
WOO 0100, 0200, 1300, 1400, 1900, 2000
NMN 0400, 1000, 1600, 2200
WOM 1230 1330 2230 2330
Southwest North Atlantic Waters
NMN 0400 1000 1600 2200
NEW ORLEANS
Gulf of Mexico
MIAMI
WOM 1230 1330 2230 2330
NMN 0400 1000 1600 2200
Southwest North Atlantic Waters
SAN JUAN
WLO 0500 1100 1700 2300
Sea
Caribbean
WOM 1230 1330 2230 2330
NMN 0400 1000 1600 2200
ALASKA
KGD 58 0200, 1500
KGD 91 0300, 1600
WBH 29 0400, 1800
KCI 95 0800, 2200
Gulf of Alaska
NOJ 0200, 0445, 0900, 1415, 1645, 2100
HAWAII
HONOLULU
(Offshore waters within 1000 miles of Hawaiian Is.)
LEGEND
Forecast Office

NMC 4428.7, 8765.4, 13113.2, 17307.3
WWD 4409.4, 8789.6, 13147.5
NOJ 6521.8
KGD 58, KGD 91, WBH 29, KCI 95 4134.9
KMI 4357.4, 8728.2, 8784.0, 13100.8, 13187.6, 17236.0

WOM 1230-4363.6, 8722, 13116.3, 17232.9
1330-4391.5, 8731.3, 13122.5, 17257.7
2230-4407, 8746.8, 13125.6, 17260.8
2330-4425.6, 8793.9, 17263.9

NMN 4428.7, 6506.4, 8765.4, 13113.2, 17307.3

WOO 0100, 1300, 1900, 4385.3, 8740.6, 13107.0, 17245.3, 22596.0, 0200, 1400, 2000, 4403.9, 8762.3, 13131.8, 17310.4, 22623.9

Figure 31.--U.S. offshore marine weather broadcasts - radiotelephone.

# Hurricane Alley

Dick DeAngelis
Environmental Data and Information Service, NOAA
Washington, D.C.

## NORTH INDIAN OCEAN AND SOUTHERN HEMISPHERE MAY AND JUNE 1978

There was very little activity in these basins during May and June. A depression in May in the Bay of Bengal and one during June in the Arabian Sea were all that have been reported.

## SOUTH INDIAN OCEAN TROPICAL CYCLONES 1976-77

This summary is based on information contained in Saison Cyclonique 1976-77 furnished by the Meteorological Service of La Reunion. The translation was kindly done by Vicki Jones of EDIS.

The season began early with Agathe forming in

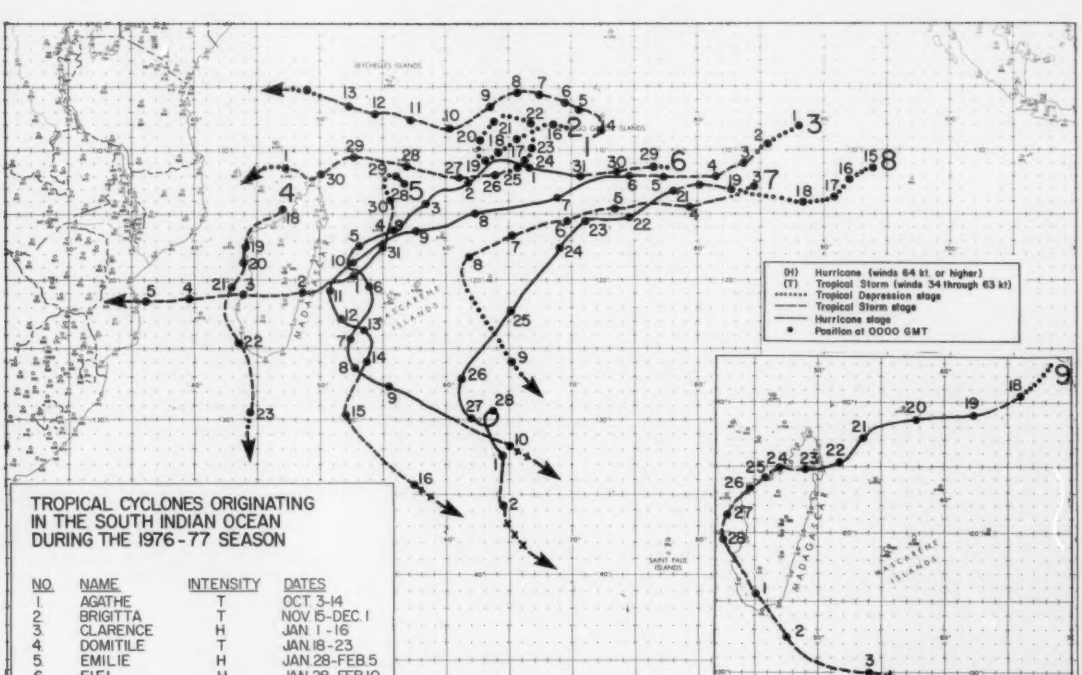

TROPICAL CYCLONES ORIGINATING
IN THE SOUTH INDIAN OCEAN
DURING THE 1976-77 SEASON
NO. NAME INTENSITY DATES
1. AGATHE T OCT. 3-14
2. BRIGITTA T NOV. 15-DEC. 1
3. CLARENCE H JAN. 1-16
4. DOMITILE T JAN. 18-23
5. EMILIE H JAN. 28-FEB. 5
6. FIFI H JAN. 28-FEB. 10
7. GILDA T FEB. 3-9
8. IO (JACK) H FEB. 15-MAR. 2
9. HERVEA H FEB. 17-MAR. 3
(H) Hurricane (winds 64 kt. or higher)
(T) Tropical Storm (winds 34 through 63 kt)
Tropical Depression stage
Tropical Storm stage
Hurricane stage
Position at 0000 GMT
SEYCHELLES ISLANDS
COMORO ISLANDS
MADAGASCAR
MASCARENE ISLANDS
SAINT PAUL ISLANDS
REUNION ISLANDS

Figure 32.--Tropical cyclones originating in the South Indian Ocean, 1976-77. Io originated in the western Australia region as Jack.

October. It ended early with Hervea on March 3. Nine tropical cyclones formed. Five reached hurricane strength. Figure 32 shows the tracks, and table 3 provides a summary.

Io, a 935 mb storm, was the strongest. Winds were estimated at 135 kn, gusts at 160 kn. A ship 150 mi south-southeast of the storm on February 25 had 45-ft seas. Io did not affect the Mascareignes. Hurricane Hervea had the same lifespan, at the same time, as Io (fig. 33). Hervea, however, did cause some problems on land. After dumping flood-generating rains over Agalega, she moved onto Madagascar. On the 22d Antalaha recorded a 986-mb pressure along with 97-kn winds for 3 hr. On the small island of Saint Marie, more than 100 mi south of the storm's center, gusts climbed to 70 kn. Majunga reported 97-kn gusts several times, and this was exceeded at several places along the southern coast on March 1. Gusts along the southwest coast ranged from 50 to 70 kn.

Madagascar was also affected by Domitile and Emilie (fig. 34). Domitile brought 65-kn winds to Majunga on the 18th of January and 50- to 55-kn winds to Morondava, Morombe, and Faux-Cap on the 21st and 22d. Torrential rains plagued the area. Morondava reported 22.7 in in 24 hr. Emilie's effect was greatest on the east coast where she brought 76-kn gusts to Mananjary. Morondava was raked by 70-kn wind gusts. Previously, Emilie had generated gales and torrential rains on Tromelin. While she was

Table 3.--South Indian Ocean tropical cyclones, 1976-77

| No. | Name | Intensity | Dates | Maximum estimated winds (kn) | Lowest estimated pressure (mb) |
|---|---|---|---|---|---|
| 1 | Agathe | T | Oct. 3-13 | 55 | 995 |
| 2 | Brigitta | T | Nov. 16-Dec. 1 | 45 | 1000 |
| 3 | Clarence | H | Jan. 5-16 | 110 | 960 |
| 4 | Domitile | T | Jan. 18-23 | 55 | 992 |
| 5 | Emilie | H | Jan. 26-Feb. 5 | 95 | 980 |
| 6 | Fifi | H | Jan. 29-Feb. 10 | 80 | 985 |
| 7 | Gilda | T | Feb. 3-9 | 45 | 1000 |
| 8 | Io (Jack) | H | Feb. 15-March 2 | 135 | 935 |
| 9 | Hervea | H | Feb. 17-March 3 | 100 | 970 |

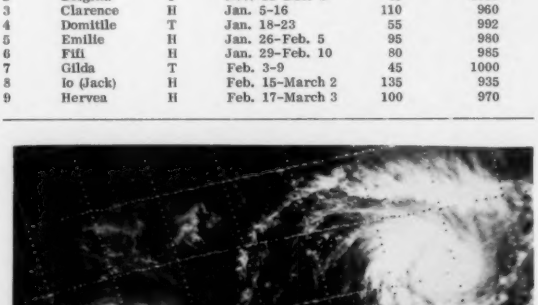



Figure 33.--Almost a replay of 3 weeks before, two hurricanes, Hervea (left) and Io, threaten the Malagasy Republic on the 22d.

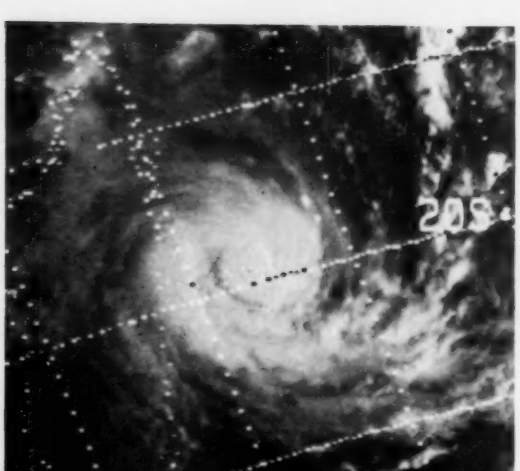


Figure 34.--Hurricane Emilie poses a threat to the Malagasy Republic on February 1.

Figure 35.--Shortly after crossing St. Brandon on the 8th, Clarence was caught along the 15th parallel by NOAA satellite cameras.

weakening over Africa in early February, she dumped up to 25 in of rain along the coast. Brigitta had some effect on northern Madagascar in late November. She was responsible for more than 15 in in 24 hr at Diego Suarez.

Clarence was most devastating to Saint Brandon. He passed 50 mi to the north at peak intensity (fig. 35). On the islands winds reached 63 kn with gusts to 90 kn. A storm surge covered one-half of the island, while winds ripped off roofs. To the north, Albatros Island lost almost all its buildings. No lives were lost. Clarence brushed Tromelin with 46-kn winds and brought Reunion 4 days of rain. Totals ranged from 32 to 54 in.

Reunion was raked by Fifi. Gillot had 52-kn gusts. Torrential rains, coming only a couple of weeks after Clarence's visit, were responsible for washing out roads and severely damaging crops, particularly geraniums and potatoes. One person died.

# On the Editor's Desk

ENVIRONMENTAL DATA AND INFORMATION SERVICE

On July 16, 1978, the Environmental Data Service officially became the Environmental Data and Information Service. EDS, therefore, is now EDIS.

The change was made to more accurately describe the organization and its functions. The Environmental Science Information Center is one of its major components. It provides literature-based scientific and technical information products and services which complement the data products and services provided by the other centers. Collectively, these centers provide a comprehensive source for both environmental data and information.

The same trend that currently characterizes scientific data management--namely, the evolution from archiving and dissemination to emphasis on applications to solve national problems--also characterizes the scientific and technical information (STI) field. STI is an essential element to EDIS environmental assessments and evaluations related to the energy crisis, environmental pollution, world food problems, climatic anomalies, and many other national and international problems.

The Mariners Weather Log is published by the National Oceanographic Data Center of EDIS with information on ship reports furnished by the National Climatic Center, another EDIS organization.

NOMINATIONS FOR SHEPHEARD AWARD

Nominations are being accepted for the third annual Rear Admiral Halert C. Shepheard Award for Achievement in Merchant Marine Safety.

The award is given either for a single outstanding contribution to merchant marine safety or for dedication to and constructive participation in activities associated with maritime safety over a period of time. Nominees may include individuals such as ship operators, naval architects and marine engineers, ship repairers, shipbuilders, and those associated with ship operations, government, or marine associations.

The award was established by the American Institute of Merchant Shipping (AIMS) in 1976 in honor of the late Admiral Shepheard, who served in the U.S. Coast Guard as Chief, Office of Merchant Marine Safety, and who was internationally acclaimed for his work in the field. The award is administered by the American

Bureau of Shipping (ABS).

Nominations should be submitted to Rear Admiral Halert C. Shepheard Award, c/o Robert T. Young, Chairman, American Bureau of Shipping, 45 Broad Street, New York, NY 10004. The deadline for receiving nominations is January 1, 1979. The award will be presented on April 17, 1979, at the ABS annual meeting at its headquarters in New York City.

The 1977 recipient was Admiral Charles P. Murphy, General Manager, Ship Construction, Sea-Land Service Inc., and the 1976 recipient of the award was John L. Horton, Manager, Marine Division of Cleveland Cliffs Iron Company.

## VITAL WEATHER SATELLITE LAUNCHED

A carefully controlled series of space maneuvers began on June 16, 1978, with the successful launch by NASA from Kennedy Space Center of NOAA's GOES-C geostationary satellite. The satellite is a key element in the Global Weather Experiment, a worldwide, yearlong accumulation of meteorological and oceanographic data which begins in December.

The largest international scientific experiment in history, with 140 nations participating, the Global Weather Experiment depends upon information collected from many sources. Oceanographic and wind observations all over the world will be made by nine satellites and scores of ships and aircraft, while thousands of surface and upper air observations will be made daily by several hundred buoys distributed in the Southern Hemisphere and by conventional observation methods elsewhere on Earth.

The experiment is a part of the Global Atmospheric Research Program (GARP), sponsored by the World Meteorological Organization of the United Nations and the International Council of Scientific Unions. It will be conducted throughout 1979, providing scientists with millions of pieces of information from all over the world.

The GOES-C spacecraft will play a major role in providing Western Hemisphere coverage for the experiment and will provide important meteorological information from a data-sparse area of the world centered on the Indian Ocean.

GOES-C, which was renamed GOES-3 once successful orbit at 22,300 mi (35,750 km) was achieved, replaced another NOAA geostationary satellite positioned at 135°W to observe much of the Pacific Ocean and the western half of the United States in late July. GOES-1 is being moved by stages almost halfway around the Earth to about 60° longitude. It will be shifted first to 15°W over the Atlantic Ocean, where it will remain under the control of NOAA's National Environmental Satellite Service Command and Data Acquisition Station in Wallops, Va. Space technologists at a new acquisition station being installed in Spain by the European Space Agency will participate in control of the spacecraft for familiarization purposes. About November 1, GOES-1 will be in position over the Indian Ocean, fully under control of the Spanish station and ready to begin providing information for the Global Weather Experiment.

The new satellite is almost identical to four earlier geostationary environmental monitoring satellites launched by the United States since 1974. Like its predecessors, it will provide a variety of imagery of North and South America and much of the Atlantic and Pacific Oceans every half hour. The imagery is used by meteorologists in weather forecasting, wind and cloud cover analysis, severe storm warning and hurricane tracking, and other activities. Oceanographers use information from the spacecraft for ocean current analysis, ship routing, and other purposes, while hydrologists find the information valuable for snow melt and snow area determination, water resource management, and various agricultural applications.

In addition, the GOES series spacecraft collect and transmit information recorded by data collection platforms at remote places on land, on buoys in the ocean, and carried aloft by balloons and aircraft. They also measure solar activity, detect solar flares, and determine the intensity of solar winds and the strength and direction of the Earth's magnetic field.

GOES-3 was boosted into orbit by a three-stage Delta launch vehicle and initially was controlled by NASA's Goddard Space Flight Center in Greenbelt, Md. It is expected to be the last NOAA geostationary satellite to be launched atop a rocket. Three more geostationary spacecraft planned in the next 8 yr will be carried into space on NASA's Space Shuttle, beginning with GOES-D anticipated in late 1980.

## METRIC CHART OF LAKE ONTARIO

The first U.S. metric chart of Lake Ontario is now available to mariners. Compiled by the Canadian Hydrographic Service and printed by NOAA's National Ocean Survey, the new chart is the result of a cooperative effort between NOS and Canadian charting authorities to standardize nautical information.

The United States and Canada have cooperated in marine surveys and charting of coastal and inland navigation routes of mutual interest for many years. A joint advisory committee was set up in 1963 by the U.S. Lake Survey and the Canadian Hydrographic Service to assess the complex technical problems involved in reducing duplication of effort and in preparing common standards of presentation and procedure.

In addition to the economies achieved by the cooperative plan, the move is welcomed by ships' navigators who will be able to interchange U.S. and Canadian charts along a route and find a large degree of uniformity in the charts.

The new chart of Lake Ontario includes the use of new colors and is constructed on the Mercator projection. It is printed on the back of the conventional chart and generally follows the guidelines established for medium-scale international nautical charts.

The chart of Lake Ontario (No. 14800) costs $3.25 and can be ordered from National Ocean Survey, NOAA, Distribution Division (C44), Riverdale, MD 20840. A check or money order (in U.S. funds) made out to the Department of Commerce/NOS should accompany the order.

## OCEAN BUOYS TESTED ON A FERRIS WHEEL

The 40-ft ferris wheel at Marshall Hall Amusement Park in Maryland was used recently by NOAA to test six buoys designed to monitor wave conditions along the Delaware and Maryland coasts this fall.

The National Ocean Survey (NOS) will deploy three 2-1/2-ft diameter buoys off the Chesapeake Bay entrance, Delaware Bay entrance, and Ocean City, Md., in water depths up to 70 ft where wave heights may be as large as 40 ft. The circular motion of the ferris

Figure 36.--The antennas of two waverider buoys being tested on the 40-ft ferris wheel are tied to prevent damage as they rotate.

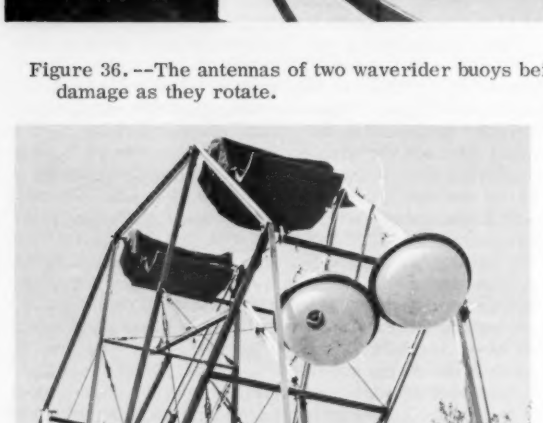


Figure 37.--Three waverider buoys rotate on the ferris wheel used for their calibration.

wheel at Marshall Hall, which simulates the motion of a floating buoy in large waves, will assist in the calibration of the buoys.

The 300-lb buoys, called waverider buoys, will provide wave information for beach erosion prevention, management and planning, safe and economical design of coastal and offshore structures, wave forecasts to vessels, and the planning of marine operations. The buoys measure wave motion with accelerometers as they move up and down with the waves. The data are radioed to a shore receiving station where it is sent via phone lines to a computer at the NOS headquarters in Rockville, Md.

The buoy calibration consisted of several phases. First, the electronics of the buoys and the receiving stations to which they transmit are thoroughly checked. Next, each buoy is placed on a special test apparatus which moves the buoy in a manner similar to wave motion. The data transmitted by each buoy are recorded and compared to the known motion of the buoy on the test apparatus.

In the laboratory these tests can only be conducted for simulated wave heights up to 4 ft. Hence, these buoys were calibrated on the 40-ft-diameter ferris

wheel at Marshall Hall Amusement Park (figs. 36 and 37). The buoy calibration was carried out by the NOS Test and Evaluation Laboratory.

FLASH FLOODS MAY CLAIM 200 LIVES THIS YEAR

Before the end of 1978 flash floods may kill 200 people and cause $1 billion in property damage. This is the average annual toll Americans have been paying to these sudden, vicious killers during the past decade. According to NOAA, flash floods have become the Nation's number one weather-related killer, outranking lightning, which was long the leader, and far outranking tornadoes and hurricanes.

According to the National Weather Service, since 1968 the average annual death toll from flash floods has been double that of the early 1960's and more than triple the rate of the 1940's. Additionally, of all the Presidential declarations of major disasters in recent years, nearly 75 percent were prompted by floods and flash floods.

Urban development along rivers and more use of narrow canyons in mountainous areas for recreation are two of the major factors contributing to the increase in deaths and damage from flash floods. In cities, the removal of vegation for buildings, roads, and parking lots has increased the peak flow rates of many small streams. Construction at streamsides often impedes the natural flow of water, adding flood hazards.

Recreational camping in mountainous areas and construction of vacation homes there have both increased greatly in the past decade, bringing with them greater potential for disaster as normally tranquil streams are turned into raging torrents by heavy summer rains.

Some of the more tragic flash floods in the past 2 yr alone show the seriousness of the problem. In July 1976, 12 in of rain in less than 6 hr triggered deadly flash floods in Big Thompson Canyon, Colo., drowning 139 persons and causing millions of dollars in property damage. In July 1977, Johnstown, Pa., suffered flash flooding which took 76 lives and caused $200 million in damage; and in November, 40 persons (half of them children) died when heavy rains over Toccoa, Ga., ruptured an earthen dam causing a flash flood which wiped out a mobile home community and part of a small college in a valley below.

Even large metropolitan areas such as Kansas City, Los Angeles, and New Orleans are not immune. In Kansas City last fall 25 lost their lives following 2 nights of extremely heavy rains. Five died in New Orleans in May when thunderstorms dropped more than 10 in on parts of the city in a few hours. A series of winter storms accompanied by heavy rains plagued southern California earlier this year, and resulting flash floods and mud slides claimed more than 30 lives.

Although radar, satellites, river and rainfall reporting networks, as well as local flash flood warning systems can go a long way to bring down the death toll from these deadly torrents, the National Weather Service notes that individual alertness is the bottom line. Unless you know what to do, watches and warnings may be meaningless. Here are the safety rules which could save your life in a flash-flood emergency.

- Keep alert to signs of wet weather; either rain where you are or signs of rain (thunder and lightning) nearby or in distant hills.

- Keep informed. Stay tuned to radio or television stations in the area for information on developing weather and flood conditions. If you are out of range of broadcast information, watch for indicators of flash flooding, such as increased speed of river or stream flow and rapid rises in water levels. Be prepared to move to safety.

- Stay away from natural streambeds, arroyos, and other drainage channels during and after rainstorms. Water runs off higher elevations rapidly, causing natural drainage systems to overflow with rushing flood waters and their deadly cargo of rocks, mud, smashed trees, and other debris.

- Never attempt to drive through moving water or flooded areas. If your vehicle is suddenly surrounded by water and stalls, abandon it immediately. Flood waters may rise and sweep the vehicle and its occupants away. Many deaths have resulted from attempts to move stalled vehicles.

- Stay out of flooded areas. The water may still be rising, and the current is usually swift. Never try to cross a flowing stream on foot if the water is above your knees.

- Use your maps. Know where you are and whether you are on locally low ground. Remember: You don't have to be at the bottom of a hill to be a target for the dangers of flash flooding.

- Know where the high ground is and how to get there in a hurry. Keep in mind that many roads and trails parallel existing drainage patterns and may be swept away by flood waters.

SEAWAY SETS PASSAGE DEADLINES

Oceangoing ships will not be allowed through the Welland Canal for passage into the Great Lakes after December 6, 1978, if they wish to leave the system before it closes. The final deadline for outbound vessels or ships that will winter in the Lakes at the Montreal-Lake Ontario section is December 15.

The early announcement of the deadlines reflects the authorities' desire to prevent the log-jam of tonnage seeking to exit the Seaway system that occurred last year.

The Seaway authorities are giving out warning notices that ships which, for whatever the reason, including pilotage delays, have not called at the Montreal-Lake Ontario section by the deadlines will suffer heavy financial penalties for being late. According to notices sent out in early August, ships seeking to move out through the Montreal-Lake Ontario section on December 16 would be charged an extra $20,000. On the 17th the charge would be $40,000; on the 18th it would be $60,000; and on the 19th, or thereafter, it would be $80,000.

However, passage would depend upon operational conditions at the time. Authorities left some leeway within which to call off the penalties if operational circumstances permit. Similarly, authorities also set ship power minimums which would limit the entry of vessels into Saint Lambert Lock should ice conditions develop early.

## STORMFURY 1978 TO SEED ATLANTIC HURRICANE

NOAA may seed one Atlantic hurricane during the 1978 season if the disturbance meets Project Stormfury criteria. The seeding experiment would be the first since Stormfury scientists seeded Atlantic hurricane Ginger in 1971.

To be eligible for seeding, a hurricane must be predicted to be within 700 mi (1,100 km) of the operating base--Miami or San Juan--for at least 12 hr, and maximum winds in the storm must be at least 65 kn.

Seeding would not be done if the hurricane had more than a 10-percent probability of approaching with 50 mi of a populated land area within 24 hr of seeding. This prevents the effects of landfall from complicating the work of detecting the effects of seeding and allows time for seeding effects to dissipate.

Stormfury will use five aircraft--three from the NOAA Research Facilities Center, Miami, and one each from NASA and the Air Force. The Air Force aircraft will not seed but will fly a modified hurricane reconnaissance mission.

When a hurricane meets Stormfury criteria, seeding will be carried out for a 10-hr period, followed by intensive monitoring by the research aircraft of the storm's characteristics over the next 30 hr.

The technique used in Stormfury is called "dynamic seeding," which means that forces within the seeded clouds are stimulated by seeding to produce the desired result. Dynamic seeding was pioneered during earlier single-cloud seeding experiments and has been refined by NOAA's Florida Area Cumulus Experiment, conducted, like Stormfury, by the National Hurricane and Experimental Meteorology Laboratory in Coral Gables, Fla.

The theory behind the Stormfury seeding experiment is that dynamic seeding of cumulus cloud towers just outside the eyewall of the hurricane--the storm's main vertical conduit for air, moisture, and the exchange of energy that drives the storm--causes those clouds to develop vertically. The seeded clouds ultimately become a new eyewall, replacing the original one, and effectively increase the diameter of the eye. This effect, through conservation of angular momentum, should reduce the maximum winds in the hurricane.

Since much of a hurricane's damage is linked to its highest winds, scientists believe reducing those winds would significantly diminish hurricane damage. If the storm's behavior or predicted position changes so that the hurricane no longer meets Stormfury criteria, aircraft and scientists will not seed, but will fly a long-term monitoring mission, keeping the storm under virtually continuous surveillance over periods as long as 60 hr.

Dr. Robert C. Sheets of the National Hurricane and Experimental Meteorology is the scientific director of Stormfury-1978.

## OCEAN DATA BUOYS DROPPED BY PLANE

A weather data buoy system that can be dropped by parachute into the ocean from a high-flying, fast-moving aircraft has been developed by NOAA. The first such buoys are expected to be used in the 1979 Global Weather Experiment.

The buoys, transmitting pressure, water temperature, and other measurements by NOAA satellite to communications stations ashore, will provide quick information about short-fuse weather conditions such as the buildup of tropical storms. They will supplement data from existing drifting buoys.

The new buoys were developed by the Office of Ocean Engineering through its Data Buoy Office in Bay St. Louis, Miss., and tested by the Air Force, which found that they can be dropped from a transport plane flying at 2,000 ft at speeds of 140 to 160 kn. They also can be safely deployed from aircraft flying as high as 25,000 ft at speeds of about 125 kn.

The buoys will be used for scientific experiments, NOAA officials point out. Scientific packages can be attached to them for dropping over a wide area in a small space of time, permitting widespread simultaneous observations when required.

The buoy is 10 ft long with a maximum diameter of 27 in. It is constructed of marine aluminum, weighs 200 lb, and, to withstand the shock when it hits the water, has a foam-filled structure. The antenna is fabricated of fiberglass.

## IMPACT OF OCEAN MINING SEEN AS NOT SERIOUS

Measurements analyzed thus far have shown no serious impact upon the marine ecosystem from industry's first efforts to harvest manganese nodules from the Pacific Ocean floor, according to a scientific team from NOAA's Pacific Marine Environmental Laboratory in Seattle, Wash. They spent several months on board the NOAA Ship OCEANOGRAPHER monitoring test mining in the Pacific.

Stressing the preliminary nature of their conclusions, the Deep Ocean Mining Environmental Study (DOMES) project manager for NOAA, said the scientists found little persistent effects from mining operations conducted by the Ocean Management, Inc., vessel SEDCO 445. He emphasized, however, that there could be chronic long-term, low-level effects which have not yet been identified or studied.

The SEDCO was mining in an area 865 mi southeast of Hawaii in water about 15,000 ft deep. Monitoring included samples and measurements taken along the sea floor--from which the mining collector lifts manganese nodules along with some sediments and small-bottom-dwellers in vacuum-cleaner fashion--and around the plume of sediments discharged by the mining ship at the surface, as well as in the water columns between the sea floor and the surface.

Comparisons were made between factors in the discharge plumes and corresponding measurements of the undisturbed ecosystem outside the plume. The effect of the mining ship's collector on the sea floor was also observed with deep-sea cameras, and box cores were taken of the disturbed sediments to determine changes in the kind of life forms found there. These samples of life forms in and out of the plumes were collected for subsequent laboratory comparison.

Preliminary analysis of benthic (sea-floor) plume data indicated that this plume did not go far upward into the water column, rising no more than a few tens of meters above the bottom. However, the plume may increase in thickness with time and distance from the collector.

No evidence was found of significant lateral spreading in the benthic plume, although there were tentative indications that the plume moved horizontally, carried on slowly moving, deep-water currents. Considerable current-meter data remains to be analyzed, however,

before firm conclusions can be drawn regarding the movement of the benthic plume.

The NOAA investigators found evidence of a rather rapid resettling of disturbed material near the mining collector. This "repiling" of the disturbed material near its point of origin suggested that the benthic plume did not migrate over a broad area.

Surface plume data suggests that much of the particulate sediments discharged by the mining vessel at the surface settled out of the surface plume and returned to the sea floor. Dissolved constituents in the surface plume could be detected for periods of a few hours; but neither particles nor chemical differences could be detected in plume water more than 24 hr old. This may mean that the surface plume effects are transient, with no detectible difference between plume water and undisturbed water 1 or 2 days after mining.

One crucial question still to be answered is does discharged material accumulate at the pycnocline, a marked change in water density at about 180 ft which separates well-mixed surface waters from the more dense waters of the deeper sea. Another vital question is how this remote, but important, corner of the global ecosystem will be affected by not one, but fleets, of mining ships. Preliminary answers may come from further analysis of data obtained during this year's voyages. Scientists plan to revisit the area periodically to assess the rate at which the ecosystem recovers from nodule mining disturbances.

This is the second phase of the DOMES Project, which began in 1975 and is part of NOAA's Environmental Research Laboratories' Marine Eco-Systems Analysis (MESA) Program. The first phase involved a series of voyages to the tropical Pacific, where commercial mining of manganese nodules may begin in the 1980's. These early DOMES studies established baselines for life and environment in the area before mining began, so that changes produced by mining could be compared to an undisturbed background, and developed a first-order capability for predicting potential environmental effects.

## FIRST SEASAT DATA RELEASED

The first radar images from SEASAT were released in early August after completing its first month in orbit. SEASAT was launched June 26, 1978, from Vandenberg Air Force Base. It is observing the World's oceans from a 500 mi high polar orbit. An article describing the satellite and its sensors, "SEA-

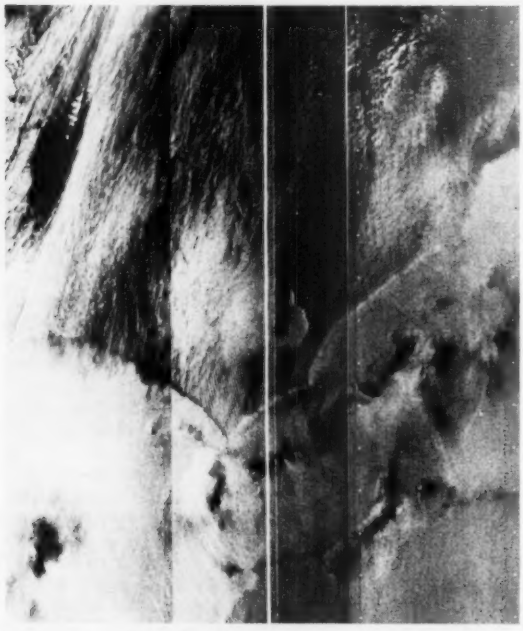


Figure 38.--This SAR image of complex ocean structure shows a portion of the Gulf Stream just off the Florida coast northeast of Miami. The image covers an area approximately 60 by 75 mi. The pattern of striations (upper left) may be related to the motion of the Gulf Stream current; the irregular pattern (lower half) may indicate the effects of wind and rainfall on the ocean's surface from a local rain squall. Ocean waves can be seen in a limited zone near the squall area (center). Although at first glance this photo appears to show clouds, the SAR sees through the atmosphere and records only reflections received from the surface. NASA Photo.

Figure 39.--This image of the Baja Peninsula coast of Mexico (right) and the Pacific (left) was obtained by SEASAT-A's SAR prior to dawn on July 7. The bright ocean areas show varied patterns including groups of internal waves and several areas of wind-roughened surface (weather maps indicated a 15- to 20-kn offshore breeze). Dark patches in the lee of the mountainous islands are areas of water sheltered from the wind. Islands shown are Santa Margarita to the south and Santa Magdalena. Agricultural fields can be seen at upper right. Tidal channels connect with Almejas Bay and Magdalena Bay. This image is a segment of a SAR swath extending some 2,500 mi along western North America to Alaska. NASA Photo.

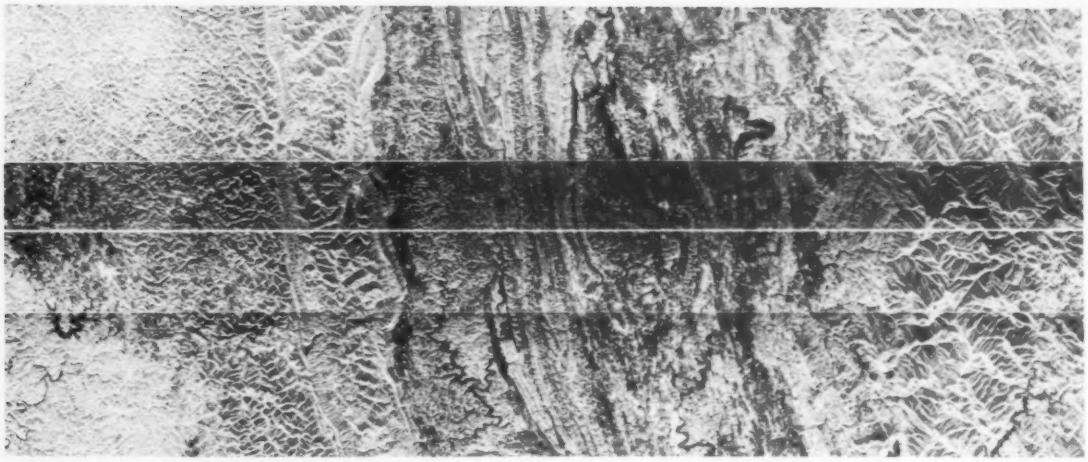


Figure 40.--This SAR image of geologic and topographic variations near Knoxville, Tenn., was obtained on July 8. Three distinctive types of topographic terrain are seen: the Smokey Mountains to the right; the folded Appalachians trending northeast (center); and the Cumberland Overthrust adjacent to the Appalachian Plateau to the left. Other features clearly recognizable are reservoirs on the Tennessee River and its tributaries. SEASAT is also capable of continental measurements with its payload of day-night, all-weather microwave sensors. NASA Photo.

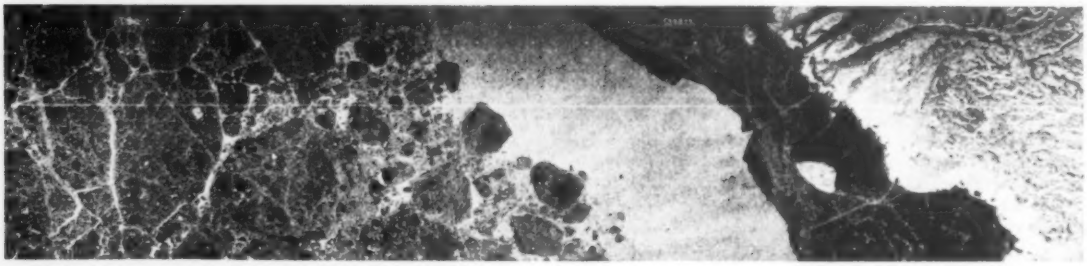


Figure 41.--This SAR image of the Beaufort Sea ice pack west of Banks Island, Canada (right), covers an area about 18 by 75 mi. The region is northeast of Alaska and some 500 mi inside the Arctic Circle. The image contains numerous ice, water, and land features. Stream channels, alluvial fans, and beaches are seen on Banks Island. The dark zone adjacent to the island is an area of shore fast ice composed primarily of first-year sea ice, 3 to 6 in thick. Linear pressure ridges are seen within the shore fast zone, and west of this zone is an area of open water, called a shore lead. At the western edge of the lead is a marginal ice zone composed of a mixture of open water and large and small rounded multi-year floes, typically 10 to 15 ft thick, and some first-year ice. Further west is the main polar pack, made up of large floes up to 12 mi in diameter, surrounded by new leads. A random pattern of pressure ridges is visible within the floes. The very bright areas within the floes indicate intensive surface roughness, called rubble fields. NASA Photo.

SAT-A and NIMBUS-G," appeared in the November 1977 issue of Mariners Weather Log.

The Synthetic Aperture Radar (SAR) is only one of five microwave sensors on board. The SAR produces "pictures" of the Earth's surface day or night under all weather conditions. It typically produces a continuous swath of images 60 mi wide by 2,500 mi long.

Figures 38, 39, 40, and 41 show the Gulf Stream off Florida, eastern North Pacific off Baja California, a mountainous region over Tennessee, and the polar ice in the Beaufort Sea off Banks Island. Examples of other SEASAT data will be published as they are released.

## HURRICANE-DANGER SURVEY RESULTS HAVE SURPRISES

When the great storm tide and winds of a hurricane threaten, those who sit tight and refuse to evacuate in spite of the danger usually are not the inexperienced coastal residents. On the contrary, a study for NOAA indicates that newcomers are more likely to evacuate when faced with a hurricane warning than are residents of the area for 5 yr or more.

This trait and other responsive actions by citizens facing a dangerous storm are helping the National Weather Service create a "profile" of those who stay and those who leave when hurricane warnings are issued.

Armed with this information, the Weather Service will be able to improve the effectiveness of its warning and preparedness programs.

When hurricane Eloise hit the Florida panhandle in 1975, 100,000 Gulf Coast residents left their homes, fleeing inland in the face of 125-mi/h winds and 18-ft storm tides. But many thousands either would not or could not leave, as Eloise moved ashore near Fort Walton Beach at 7 a.m. on September 23 and caused $200 million damage.

A few days after the storm, a cooperative study between the National Weather Service and the Social Science Research Center at Mississippi State University put a survey team into the area to learn more about the perceptions and reactions of persons to a hurricane threat and weather warning messages. This was a follow-up to a similar effort conducted by these two groups following hurricane Camille in 1969.

About half of those interviewed, according to the survey team, were newcomers, living in the area 5 yr or less. Of this group, "leavers" outnumbered the "stayers" by 5 to 1. Among residents of 6 yr or more, however, there was a 2 to 1 ratio of "leavers" to "stayers." Apparently, the researchers concluded, the newcomer to the coast is aware of his limited knowledge and experience of hurricanes and has a healthy respect for them.

In contrast to the relative newcomer, those who had lived in the area more than 5 yr, even though they had no hurricane experience, appeared to acquire an artificial experience from the area's more seasoned residents who were likely to say, "We haven't had a hurricane in 30 years." or "I've been in two hurricanes and they're not bad." or "They overdo this hurricane thing."

In making a decision to leave or stay when warned of a hurricane approaching, the "not-so-new newcomer" seems to draw from this pseudo-experience in a manner similar to that of the resident with some actual hurricane experience.

Another significant finding by the survey team was the general lack of understanding by coastal residents of the nature of a hurricane and its dangers. Hurricane winds were by far the most feared element of the storm, and this was the reason given by most people for evacuating--mentioned about three times as often as fear of water. This lack of understanding of, and respect for, storm surge is particularly significant in that 90 percent of all hurricane deaths are from drowning.

The majority of those interviewed in the Eloise survey were satisfied with the National Weather Service's warnings and their distribution by public-safety agencies and the news media.

With the data obtained from the interviews, the researchers were able to create profiles of "typical" leavers and stayers. The typical leaver had lived on the coast less than 5 yr and had no previous hurricane experience. He or she started following information about the storm somewhat earlier than the typical stayer, and was influenced by the weather warnings and the Civil Defense to leave. The leaver was more likely to have an accurate recall of the predicted windspeed and tidal height and expressed more fear of winds and water damage than most stayers.

While the typical stayer was not the complete opposite of the leaver, there were important differences. The typical stayer was not a newcomer to the area and, more often than the leaver, claimed previous hurricane experience. The stayer was less influenced by weather warnings and Civil Defense and did not believe the storm would hit until very late. The typical stayer was less knowledgeable of wind and tide predictions than most leavers, yet tended to be more dissatisfied with the information received and the warning system after the storm.

## SECOND PORT METEOROLOGICAL OFFICER FOR GREAT LAKES

Fred Day (fig. 42), Official-In-Charge of the National Weather Service Office in Sault Ste. Marie, Mich., now shares PMO duties for the Great Lakes with Bill Kennedy, PMO at Cleveland. Fred's principal area of concern is Lakes Superior and Michigan, including the Straits of Mackinac and the Soo.

The addition of another Port Meteorological Officer for the Great Lakes was prompted by NWS's desire to expand the Cooperative Ship Program in the Great Lakes; a need for strengthening the quality control techniques and inspection frequency for both Mobile Ship Stations and Shore Stations; and to provide a greater level of training for observers and users of NWS products.

Fred brings to the job a wide diversity of weather experience. A native of Detroit, his National Weather Service assignments have been Denver, Colo., King Salmon, Alaska, Cold Bay, Alaska, and Sault Ste. Marie, Mich.

For those who wish to contact the Sault Ste. Marie PMO, the telephone number is 906-632-8921; and the mailing address is National Weather Service Office, City-County Airport, Sault Ste. Marie, MI 49783.

Figure 42.--Port Meteorological Officer, Fred Day.

## WINTER STORM SAFETY ADVICE FROM NOAA

As winter approaches, accompanied by killer blizzards, freezing cold, and ice storms, NOAA suggests the time to prepare for winter hazards is now. Much can be done to avoid the threat to life posed by winter storms, and being prepared for severe weather conditions and exercising good judgement in the event they occur are of utmost importance.

The leading causes of death in winter storms, roughly in this order, are: weather-related automo-

bile accidents, heart attacks from shoveling snow, freezing, storm-induced home fires, carbon-monoxide poisoning, accidents from falls, and collapse of snow-laden buildings.

In the event of a winter storm, you should be ready to live without utilities and service. Assume there may be no electricity, no central heating, no deliveries or any way to get groceries, no way to get out of your house for a day or two--and plan accordingly. Check battery-powered equipment such as flashlights and radios and make sure batteries are fresh. Have an emergency heating system. Stock extra food, including some that requires no cooking. Look for potential fire hazards from prolonged use of stoves, fireplaces, and space heaters.

If you are able to get outside, keep.in mind that heart failure from shoveling snow is a major cause of death. Remember that mittens are warmer than fingered gloves, several layers of loose-fitting garments provide the best protection against cold, and outer wear should be tightly woven, water repellant, and hooded.

Winterize the family car. Have the ignition, fuel system, antifreeze, and exhaust system checked. Make sure the heater is working well, brakes are tight and in adjustment, tires are in good condition, and windshield wipers and lights are working properly.

In rural areas or when extended travel is planned, be ready for the worst. Keep a storm kit in your car, including tire chains, tow chain, snow shovel, sack of sand, flashlight, signal light, flares, fire extinguisher, booster cables, axe, windshield scraper, external heater, first-aid kit, knife, compass, blankets or sleeping bags, paper towels, matches, candles, extra clothing, pliers, screwdriver, and adjustable wrench. Many drivers carry a spare set of wheels equipped with chains. It's often easier to change the wheels than to install chains when a car is stuck.

If you must drive during a winter storm, keep as much gasoline in your tank as you can and stop frequently to refill. In remote areas, travel in convoy with another vehicle, if possible.

When conditions worsen rapidly, seek refuge immediately. If a blizzard traps you, try to stay in the car, where rescuers are most likely to find you the soonest. If you're stuck deep, don't try to push 2 tons of metal out of a drift or risk a heart attack by frantic shoveling. Don't try to walk to safety through a blizzard unless you are absolutely sure a shelter is nearby and you can make it. Getting lost can mean almost certain death.

While waiting for help, open a window slightly and run the motor and heater sparingly. Carbon monoxide is a stealthy killer. Try not to remain motionless for long periods. Exercise by clapping hands and moving arms and legs vigorously. At night, turn the dome light on so work crews can spot you. Keep continuous watch. Never allow all occupants of a car to sleep at once.

The National Weather Service issues travelers' advisories when conditions are expected to make traveling difficult. Before setting out, check the latest weather information. On the road, keep tuned to the radio for advisories and bulletins.

As alerting words, the Weather Services uses the terms "watch" and "warning," just as it does for hurricanes, tornadoes, flash floods, and severe thunderstorms. A glossary of winter storm terms follows.

Watch - severe winter weather may affect the area, so keep listening for the latest storm bulletins on the radio and TV and begin precautionary measures.

Warning - severe winter weather is almost certain to occur; immediate action should be taken to protect life and property.

Snow flurries - intermittent snow of short duration. Flurries may reduce visibility to 1/8 mi or less.

Snow squall - brief, intense snow comparable to a summer rainshower, accompanied by gusty winds.

Snow - in a forecast without qualifying words such as "occasional" or "intermittent," means snow probably will fall for several hours without letup.

Heavy snow - 4 in or more in 12 hr or 6 in or more in 24 hr. There are regional variations, however. Where 4-in snowfalls are common, heavy snow generally means 6 in or more in 12 hr.

Blowing snow - snow lifted from the surface so that visibility is greatly restricted.

Drifting snow - strong winds will pile the snow to traffic-impeding depths.

Blizzard - winds of at least 35 mi/h with considerable falling or blowing snow.

Severe blizzard - winds of at least 45 mi/h plus densely falling or blowing snow and temperatures of 10°F (-12°C) or lower.

Freezing rain and freezing drizzle - a coating of ice is expected on the ground and other exposed surfaces. Ice storm indicates ice coatings will damage trees and burden telephone wires. Damage will be greater if freezing rain is accompanied by high winds.

Sleet storms - frozen rain drops, smaller than hail, which bounce when hitting the ground. Sleet storms are sometimes confused with ice storms, but sleet does not stick to trees or wires. In sufficient depths, sleet makes driving hazardous.

A wind-chill chart is shown in figure 43.

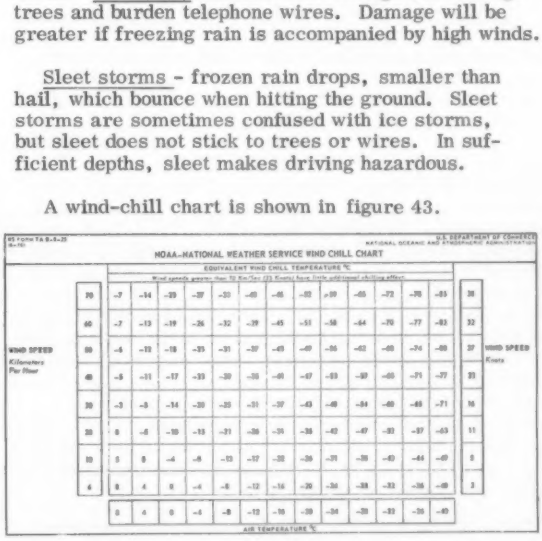



Figure 43.--Wind-chill chart in knots and degrees Celsius.

## HURRICANES ALTER AMERICAN HISTORY

As Gulf of Mexico and Atlantic Ocean coastal states brace themselves for the peak months of the hurricane season--August, September, and October--weather experts and others with long memories recall that hurricanes have altered the course of events in North America since the days of Columbus.

From 1502 until the present, the great storms have affected the lives of those living in what is now the United States and those attempting to settle the "New World."

On his fourth and final voyage to North America in 1502, Columbus correctly read the signs of an Atlantic hurricane and sought shelter in an island cove on Hispaniola. Thirty other ships, ignoring his warnings, set sail from Santo Domingo Harbor for Spain. Twenty of them, with 500 men, were never seen again.

Other early explorers--Ponce de Leon, Hernando Cortes, and English settlers bound for Virginia--also battled hurricanes, and many ships were overwhelmed. It is said a vessel was sunk for every mile of the Florida coast.

During America's long colonial period, the predominantly low-lying coastal settlements repeatedly were raked by hurricanes which often struck without warning. Homes were flooded or washed away and crops destroyed. Settlers, sailors, and travelers were killed by the hundreds, and communities were isolated for months by the ravages of the storms.

Historians know that hurricanes had an impact on the outcome of the Revolutionary War, the War of 1812, and the Civil War, as well as many other historical events. But as the newly-settled country grew, so did its understanding of hurricanes. Characteristically, Benjamin Franklin was the first to recognize that hurricanes are moving, independent entities, with winds blowing in many directions. Students later discovered that hurricane winds rotate, coiling inward around a calm "eye."

A new era opened in 1943 when the first intentional aircraft penetration of a hurricane was made by Colonel Joseph Duckworth. Today, with aircraft, radar, and, most recently, weather satellites, it is all but impossible for a hurricane to roar in unheralded upon a helpless coastal population.

With improvements in hurricane tracking and forecasting have come greatly reduced death tolls. After the terrible Galveston disaster of 1900--when 6,000 persons were drowned by a 15-ft hurricane-caused storm surge that swept over Galveston Island--the average annual toll from Atlantic hurricanes in the United States dropped to 114. Since 1930, the annual toll has averaged 64. But now forecasters fear their increased ability to detect, track, and predict the path of hurricanes is being overwhelmed by growing population density along the coast. The traditional minimum of 12 daylight hours of warning time, they feel, will not be enough to complete evacuation of threatened areas and avoid a major catastrophe.

The National Hurricane Center lists 18 hurricanes that have killed 50 or more people in the United States since the Galveston storm in 1900:

September 1909 - 350 persons killed by storm surge west of New Orleans, La.

August 1915 - 275 persons killed in Galveston, Tex., by storm surge.

September 1915 - 275 killed south of New Orleans in a storm that destroyed 90 percent of the buildings over a large area.

September 1919 - 287 killed by a hurricane tearing through Florida and Texas, with more than 500 others lost at sea in the Gulf of Mexico.

September 1926 - 243 killed in Miami area and from Pensacola to southern Alabama by a Gulf-hopping hurricane.

September 1928 - 1,836 fatalities after hurricane winds caused Lake Okeechobee, Fla., to spill over into populated areas.

August and September 1935 - The "Labor Day Storm" whose 200 mi/h winds caused 408 deaths in southern Florida.

September 1938 - 600 residents of New England and Long Island killed by winds and storm surge.

August 1940 - 50 killed in southeastern United States from Georgia as far inland as Tennessee, 30 due to hurricane-caused floods.

September 1947 - 51 deaths in Florida, Louisiana, and Mississippi.

August 1954 - 60 fatalities caused by hurricane Carol sweeping from North Carolina to New England, with $500 million in property damage.

October 1954 - Hurricane Hazel caused 95 deaths from South Carolina to New York, in the season's second severe hurricane.

August 1955 - 184 deaths throughout the Northeast as hurricane Diane caused severe flooding.

June 1957 - 381 persons killed from Texas to Alabama, with a 12-ft storm surge inundating Louisiana 25 mi inland, destroying many homes.

August and September 1960 - 50 fatalities caused by hurricane Donna in Florida and New England.

August and September 1965 - 75 killed and extensive damage in southern Florida and Louisiana.

August 1969 - 255 known dead, 68 others missing and presumed dead in Gulf Coast states and Virginia from hurricane Camille's 24-ft Gulf of Mexico storm surge and flooding in Virginia caused by 27 in of rain in 8 hr.

June 1972 - 122 fatalities as hurricane Agnes caused devastating floods from North Carolina to New York, and spawned 17 tornadoes in Florida and Georgia. More than $2 billion damage in one of the costliest natural disasters in U.S. history.

## PUBLICATIONS OF INTEREST TO MARINERS

NEW NAVY ATLAS FOR THE SOUTH ATLANTIC

The U.S. Navy Marine Climatic Atlas of the World, Volume IV, South Atlantic Ocean (Revised 1978) NAVAIR 50-1C-531, is now available through the Superintendent of Documents, U.S. Government Printing Office, Wash., DC 20402. The GPO Stock Number is 008-042-00069-1.

The eight-volume series, U.S. Navy Marine Climatic Atlas of the World, has had wide acceptance as an authoritative reference for large-scale operational planning and applied research. This updated version of the 1958 Volume IV includes nearly 20 yr of additional data. It is not a one-for-one revision of the 1958 atlas, however. Some of the data presentations have been changed, and wave statistics have been added. No upper air charts are presented since in recent years several comprehensive volumes of upper air data have been published separately.

Data for the atlases in this series are obtained from ships' weather observations. There are vast areas where transient ships' logs of surface weather observations are the only source of detailed knowledge of ocean climate. The National Climatic Center has taken ship observations collected by the major maritime nations and placed them into one tape deck, Tape Data Family-11 (TDF-11), in a common format. This tape deck was used in the computations in this volume.

The atlas is a monthly, seasonally for some oceanographic data, presentation of isopleth analyses supplemented by graphs and tables. The analyses were completed by a team of analysts under the leadership of R.G. Quayle, J.D. Elms, and D.C. Fulbright. The basic maps were automatically plotted from 1- or 2-degree square summaries for the entire ocean area. To supplement the isopleth analyses, graphs and tables are presented for selected representative areas.

The atlas contains analyses of winds, air and sea temperatures, precipitation, cloudiness, visibility, humidity, pressure, and waves. Some of these parameters are also analyzed in various combinations. The oceanographic section presents information on tides and currents.

This volume is the fourth of the series. Volumes covering the Atlantic Ocean (Volume I), the North Pacific Ocean (Volume II), and the Indian Ocean (Volume III) have already been published.

## LETTERS TO THE EDITOR

DEEP SEA MINER II AND TROPICAL STORM BUD

The following letter was received from Captain Norman G. Cubberly who was aboard the DEEPSEA MINER II when she encountered Bud in the eastern North Pacific.

DEEPSEA VENTURES, INC., GLOUCESTER POINT, VIRGINIA 23062

July 17, 1978

Mr. Elwyn E. Wilson
Mariners Weather Log
Washington, D.C. 20235

Dear Mr. Wilson:

This is to inform the Mariners Weather Log that Bud, the first tropical storm in history to bear a male name was ridden out by the R/V DEEPSEA MINER II (5MBE) on June 18, 1978, at approximately 14°37'N, 125°18'W (fig. 44). The eye was seen on radar, clearly circular about 18 mi across passing 34 mi to the south of our position and moving west at about 12 kn. We were hove to, head-to-sea protecting a string of instrumented pipe several thousand feet long. We took no heavy water on deck and suffered only minor damage when our plastic cloth "dome" split in a maximum gust of about 50 kn at 0600. The dome protects our pipe-handling equipment from the weather.

I was aboard as Chief "Mining Pilot" and personally made the enclosed maneuvering plot from radar. Also enclosed is a copy of the barogram covering BUD (fig. 45) and the final avoidance maneuver after pipe recovery to clear Carlotta (fig. 46).

Very truly yours,

Norman G. Cubberly
Port Captain

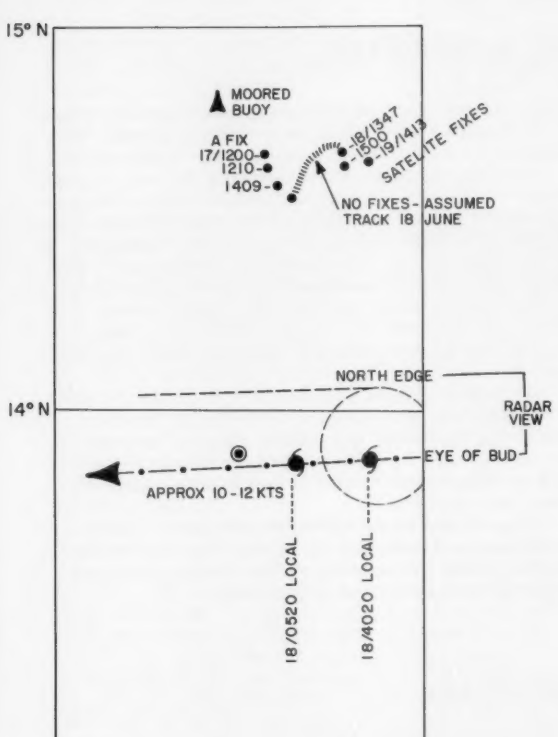



Figure 44. -- The approximate track of the DEEPSEA MINER as Bud passed to the south.

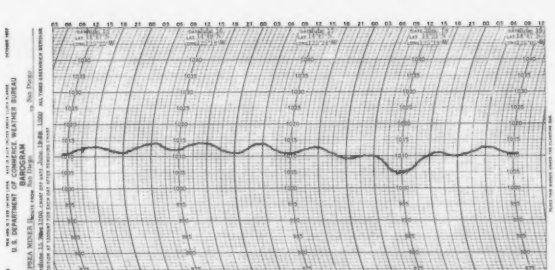


Figure 45. -- The barogram of the DEEPSEA MINER, June 15-19, 1978.

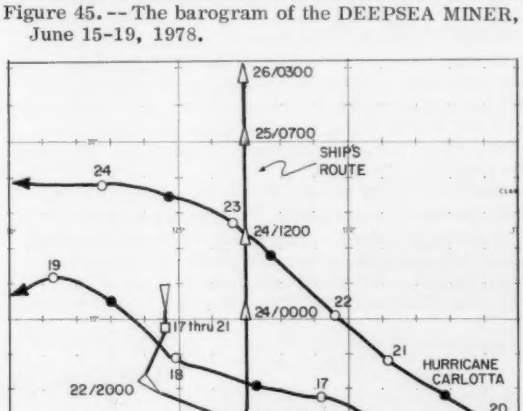



Figure 46. --Track of the DEEPSEA MINER to avoid Carlotta.

# MARINE WEATHER REVIEW

The SMOOTH LOG (complete with cyclone tracks [figs. 49-52], climatological data from U.S. Ocean Buoys [table 4], and gale and wave tables 5and 6), is a definitive report on average monthly weather systems, the primary storms which affected marine areas, and late-reported ship casualties for 2 mo. The ROUGH LOG is a preliminary account of the weather for 2 more recent months, prepared as soon as the necessary meteorological analyses and other data become available. For both the SMOOTH and ROUGH LOGS, storms are discussed during the month in which they first developed. Unless stated otherwise, all winds are sustained winds and not wind gusts.

## Smooth Log, North Atlantic Weather

### March and April 1978

SMOOTH LOG, MARCH 1978--The primary cyclone-center track across the ocean was from Newfoundland to the Faeroe Islands. This was farther south than the climatological track for this month. It normally extends from Hamilton Inlet to Iceland with another from Newfoundland to midocean. The paths which feed into the actual Newfcundland gate were also different. There was a three-storm track up the Atlantic coast with several more farther east at sea. Two paths came across the northern United States and southern Canada--one across the Great Lakes and the other across James Bay. These two

joined over Newfoundland and, of course, there were mavericks that branched off. There was no specific pattern to the storm centers that penetrated Europe. There were two centers over the eastern Mediterranean Sea.

The monthly mean sea level pressure pattern helps explain the paths of the cyclone centers. The Icelandic Low was near 61°N, 26°W, about 500 mi east-northeast of its normal location, and 15 mb lower in pressure. The Azores High was 8 mb higher in pressure near 36°N, 22°W, and at least 800 mi northeast of its normal position.

These pressure variations and locations produced some large anomaly centers. There was a -16 mb near 60°N, 25°W, a -13 mb over the Greenland icecap, and a +10 mb near 37°N, 20°W. Over the eastern United States the pressure was slightly higher over the northern plains and south of the Great Lakes.

In the upper air at the 700-mb surface the primary center of circulation was near its normal position over Baffin Island, but there was an anomalous trough and LOW above the surface Icelandic Low. There is normally a slight ridging near Iceland that extends southward approximating longitude 5°W. This ridging was wiped out except along the coast of Portugal. From Newfoundland to Florida the constant pressure surface heights were nearly identical with climatology.

Extratropical Cyclones--This frontal wave was analyzed on the first chart of the month off Charleston, S.C. There were seven ship reports in the area. By 1200 on the 2d the LOW was 975 mb near 41°N, 54°W. At 1800 the CRANIA had winds over 50 kn south of the storm, and the LETCHWORTH had following 33-ft swells in the far southwestern quadrant at 35°N, 70°W. On the 3d there were many 50-kn and over wind reports in all quadrants. At 1200 the CLYTONEUS and POST CHAMPION took the honors with 40-ft swell waves along 40°N between 49°W and 53°W. At 1800 the DART ATLANTIC (43°N, 46°W) was due south of the 948-mb center with 65-kn winds and 33-ft waves, which increased to 75 kn and 40 ft at 0000 on the 4th. The POST CHAMPION now had 60-kn winds and 49-ft swells, while the GREAT REPUBLIC (35°N, 46°W) was pounded by 52-ft swells. Many ships were indicating they were stationary and riding out the storm. There were seven reports at 1200 on the 4th of winds greater than 50 kn and all had seas and/or swells of over 30 ft. The winds ranged as high as 63 kn, with these reports scattered over the area of 40° to 48°N and 37° to 50°W. East of the storm the winds rose to 45 kn and the seas to 20 ft. By 0000 on the 5th the storm was 966 mb at 53°N, 35°W. The PROTSIONE (53°N, 28°W) had 64-kn winds on her starboard side. The sea and swell reports were generally in the 20- to 25-ft range, but the HOEGH ORRIS near 40°N, 43°W, at 1200 found 42.5-ft swells. Twenty-four hours earlier they had been 49 ft a few miles to the east. At this time another LOW was over Newfoundland and moving northeastward. The original storm was now traveling due north and weakening. By the 6th the new storm was the primary one, but the other continued north of Iceland and finally into northern Norway.

This was the storm that replaced the last one. It started near Savannah, Ga., on the 3d and traveled up the coast. The MONTICELLO VICTORY was south of the center and east of the cold front near 33°N, 76°W. The southerly winds were 60 kn with 20-ft waves. On the 5th at 0600 a ship coded LF3Q (43.5°N, 60°W) was near the center of the 972-mb storm. Its pressure was 984 mb with 60-kn winds and 25-ft seas. At 1200 a Danish ship near 64°N, 54°W, reported 80-kn northerly winds. On the 6th the storm turned westerly and made a counterclockwise loop around Newfoundland. It was now a very large storm that reached eastward to Ireland. There were many strong winds of over 50 kn north of the center over the Labrador Sea. The JOHN CABOT had 65-kn winds with 31-ft swells near 57°N, 56°W. Another Canadian ship nearby had 56 kn with 31-ft waves. Winds of over 50 kn extended as far south as 30°N. The FROSTFJORD (42°N, 24°W) at least 1,400 mi southeast of the center reported 76-kn winds as a frontal wave moved northwest of her. On the 7th the AMBARTCHIK (50°N, 50°W) was blasted by below-freezing 76-kn winds. It was probably too cold to estimate the waves. There were still reports of storm winds and seas up to 25 ft in all except the eastern quadrant of the storm. The IMPERIAL ACADIA in the Gulf of St. Lawrence was ravaged by 80-kn winds. The 366-ton Panamanian-registered MORUKA became disabled and beset by heavy weather about 300 mi east of Bermuda. The DOLLY SKOU relayed her distress to the U.S. Coast Guard. AMVER located the MINERAL HOBOKEN as being in the best position to offer assistance. The MORUKA was taking increasingly heavy rolls in force 9 seas, and on the 8th the eight crewmen abandoned ship and boarded the MINERAL HOBOKEN. The storm suddenly turned northward after completing the loop. It dissipated off Greenland on the 10th as it broke into multiple centers.

Monster of the Month--Several small LOWs over the southern States merged into one center on the 10th near Cape Hatteras. Gale-force winds were blowing on the 11th as the third storm moved along the U.S. East Coast. At 1800 the storm center passed almost directly over the NNXX near 46°N, 56°W. The storm's pressure was 982 mb, and the ship's was 988 with 50-kn winds. At 1200 on the 12th the storm had two centers. A ship with only partial call letters near 45°N, 44°W, had 50-kn winds. The FAIZA (39°N, 45°W) had 41-ft swells and 20-ft wind seas.

The double-centered LOW persisted. At 1200 on the 13th one center was 974 mb at 57°N, 23°W, and the other 972 mb at 53°N, 20°W. The high waves also persisted. The C.P. VOYAGEUR had 35-kn winds with 30-ft swells, the FINA NORVEGE 55 kn

and 23-ft waves, and the ORDUNA had 50-kn winds with 16-ft seas and 49-ft swells south of the center near 46°N, 22°W. At 1800 the AMERICAN LEGEND suffered 39-ft seas driven by 60-kn winds. Ocean Station Vessel Romeo reported devastating 45-kn winds and 43-ft seas at 0000 on the 14th. I wonder if they were able to launch their upper air sounding balloon? At 1200 the high waves had hit Lima, but they were only 28 ft. The northern center was now tracking northwestward, while the southern center continued into the North Sea. The AMERICAN LEGEND was following the storm and continued to have 55-kn winds and 39-ft seas. On the 15th the northern center was the primary storm as far as shipping was concerned. The Ocean Weather Stations were still being hit; Charlie had 33-ft swells and Romeo 30 ft. Other ships were suffering the same fate. On the 16th both old LOWs suddenly filled, and a new center developed over Scotland, but the 25- to 30-ft seas continued. The ATLANTIC CONVEYOR was sailing westward out of the storm but still had 50-kn winds and 30-ft waves. Romeo now was tossed by 33-ft seas.

On the morning of the 16th the 233,690-ton Liberian-registered tanker AMOCO CADIZ fully loaded with 1.5 million barrels of oil was 9.5 mi off the island of Ushant. She was headed for Wales from the Persian Gulf. At 1045 the rudder reportedly stopped answering the helm. Attempts were made to engage the backup system but could not be accomplished owing to the pounding seas. A tug fixed a towline around 1415, but it broke about 1715. Several more towing attempts failed, and the huge tanker went aground at 2204 at high tide. Helicopters took 42 of the 44 crewmen off. The captain and another officer remained aboard. On the 17th the tanker broke in two, and oil spilled from its tanks (fig. 47). The two remaining crewmembers were also rescued. Attempts to bring smaller tankers close enough to pump oil from the secure tanks were foiled by rough weather and seas. Massive cleanup operations were started, and the remaining oil was released by dropping explosives. This was the largest oil spill in history. The tanker OLYMPIC BRAVERY, in ballast, developed engine trouble in January 1976 and went aground and broke up near the same island.

On the 17th the storm crossed the Baltic Sea, and a new storm was brewing in the west.

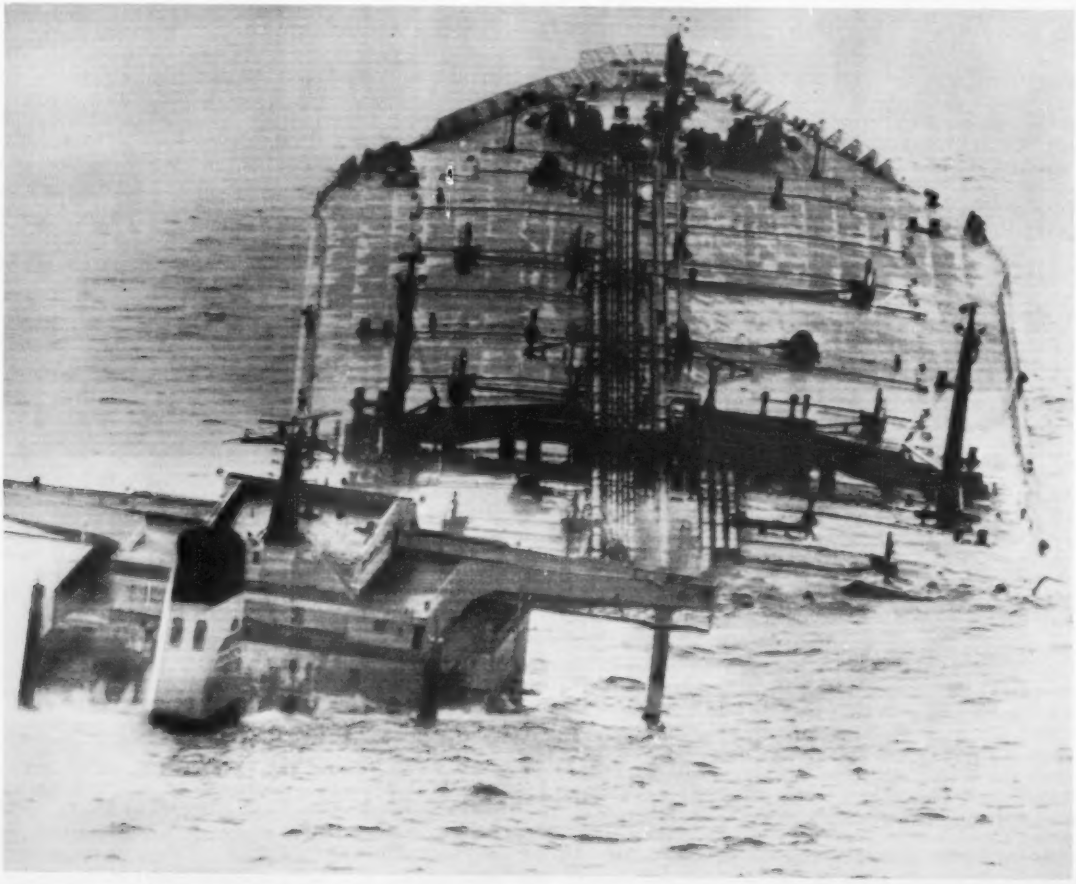


Figure 47.--This is a water-level view of the AMOCO CADIZ as she appeared on March 18 after breaking in half. Wide World Photo.

This storm came out of the Midwest south of Chicago. It traveled northeastward up the St. Lawrence River Valley and crossed the Strait of Belle Isle on the 16th. At 0000 on the 17th the 978-mb center was at 55°N, 47°W. The JOHN CABOT was north of St. John's(50°N, 50°W) and blasted by 55-kn freezing winds. The LINDA DAN was fighting 68-kn winds and 33-ft seas off Kap Farvel. The HUDSON was near the edge of the ice on the Labrador Sea with 21-ft seas.

As the LOW moved over the southern tip of Greenland it split into two centers, one on each side of the ice cap with the eastern one surviving until the 19th. The maximum winds appeared to be near 50 kn. Several secondary LOWs formed to the south and east and moved around the periphery. At 0000 a ship near 54°N, 33°W, reported 54-kn winds and 26-ft seas. At 0600 OWS Lima measured roaring 65-kn winds and 43-ft seas, and at 1200 the seas had increased to 49 ft. Other ships plotted 20- to 25-ft seas and swells. On the 20th a secondary LOW that developed near Keflavik became the primary center of circulation. The winds and waves had reached the North Sea with 50- to 60-kn winds and seas to 33 ft. A ship near 52°N, 37°W, had 50-kn winds and 25-ft seas. Lima was now measuring 30-ft seas. Charlie reported 30-ft swells.

The LOW was moving northeastward and a trough relieved the pressure gradient over the North Sea, but the storm winds continued south of Iceland. On the 21st the LOW disappeared as another moved south of Kap Farvel.

This storm formed over Labrador south of another that had tracked across the Yukon Territory and continued into the Labrador Sea. At 1200 on the 20th the 992-mb center was near Mary's Harbour. The DART AMERICA was at 45°N, 55°W, with 53-kn winds and 26-ft seas at 1800. On the 21st the JOHN CABOT was still near the same position north of St. John's with 63-kn winds. Charlie had 45-kn gales and waves up to 28 ft. The AMSTELMEER (48°N, 31°W) and ATLANTIC COGNAC (48°N, 40°W) had winds of 50 kn or more and seas of 36 ft and 33 ft, respectively. At 0000 on the 22d, the 970-mb LOW was 400 mi east of Kap Farvel. Mostly the winds were in the 40- to 50-kn range, but many swell reports were near 30 ft in the south and southwest quadrants. SHIP reports at 0300 and 0600, which were probably OWS Charlie, showed 52- to 60-kn winds and 28- to 36-ft waves. On the 22d and 23d the AMERICAN ARCHER was sailing along 47°N between 29° and 38°W with 41-ft swells varying in direction from 270° to 220°. Its sister ship, the AMERICAN LEGEND, was following near 15°W and measured 55-kn winds and 33-ft seas.

At 1200 on the 23d the LOW was 980 mb southeast of Iceland, and another center had formed over the North Sea. OWS Lima radioed 45-kn winds and 38-ft seas. On the 24th the new center took over and another LOW was south of the Denmark Strait. This continued the westerly flow and fetch south of latitude 50°N. On the 24th and 25th the AMERICAN ARCHER moved from approximately 40°W to 55°W along 45°N. The wind waves were about 13 ft but the swell waves were up to 41 ft shifting from a southwest to a northwest direction.

This LOW also originated in Yukon Territory and followed in the track of the other storm. At James Bay it jumped southeastward out of the track to the Gulf of St. Lawrence. At 1200 on the 25th the 994-mb storm was centered near 49°N, 52°W--a small storm. As the eastern circulation moved over the warmer Atlantic waters, the storm deepened rapidly. The JOHN CABOT was faithfully reporting winds of near 50 kn from near 51°N, 52°W. At 1800 on the 26th the EUROFREIGHTER (51°N, 27°W) had 60-kn winds and 38-ft seas, while Charlie measured 64-kn winds, 28-ft seas, and 44-ft swells. Her winds had decreased to 50 kn, seas 30 ft, and the swells 44 ft 6 hr later. The AMERICAN ALLIANCE had seas of 16 to 20 ft and swells of 37 to 41 ft on the 26th and 27th as she sailed westward in the vicinity of 46°N, 35°W. At 1200 on the 27th there were five reports of seas or swells of 30 ft or more around the southern half of the storm. The high waves were in a northwest-southeast-oriented band that was moving eastward with the storm. The band was wide enough to keep Charlie in it until the 29th at which time they fell to a pleasant 20 ft. On the 30th the weakening storm was moving up the Norwegian coast and no longer of concern.

A front swept off the U.S. East Coast and joined with a LOW that was associated with an inverted trough south of Bermuda on the 30th. The storm moved fairly quickly northeastward and grew. On April 1 the DART ATLANTIC was near 43°N, 56°W, with northwesterly 55-kn winds. The EXPORT LEADER was headed toward Nantucket. They must have passed almost directly through the center of the storm about 0330 as indicated by their barograph, which plunged to 970 mb and immediately started to rise rapidly. A note on the barograph indicated 70- to 80-kn winds. Their 0600 observation indicated 65-kn winds from 290°. The following notation was in the remarks column: "0318Z SW-10-12 976.4 mb, 0330Z NW 10-12 972 mb." No wave reports were logged during this period. The TAIFUN (46°N, 44°W) was lashed by 80-kn winds and 38-ft seas and swells according to her 1200 report. At 0000 on the 2d, she reported 60-kn winds with 33-ft seas and 36-ft swells. Many ships were reporting winds over 40 kn and seas over 20 ft. As the storm approached 60°N on the 3d, it was deteriorating rapidly.

Casualties--The 7,062-ton Greek cargo vessel DAPO ALECOS reported heavy weather damage during a February 24 to March 8 voyage. The British vessel FINNISH WASA (15,773 tons) reported heavy weather damage at Port Canaveral on the 7th on a voyage from Hamburg. The LADY VICTORIA (10,970 tons) of Panamanian registry arrived St. Michael's on the 5th with weather damage. The 1,950-ton SECIL BRASIL of Angola registry arrived Corunna from the United States on the 15th for shelter repairs. Four persons were slightly injured. The 14,840-ton Greek cargo vessel ANNA arrived Acajutla on the 16th with alleged heavy weather damages. The 1,350-ton Russian KABONA was purposely grounded near Landsort on the 17th because of cargo shifting in heavy weather.

The British cargo vessel KIRRIEMOOR (22,198 tons) was surveyed at Halifax owing to heavy weather from the 12th to the 21st while London to Halifax. The American MERRIMAC (15,995 tons) sustained heavy weather damage and had to unload part of her grain cargo. The 24,175-ton Liberian-registered MANITOBA 1 was under repair in New Orleans for heavy weather dam-

age to rudder and forward superstructure owing to heavy weather on a February-March voyage. The crew of the 4,547-ton Greek freighter SARBO was rescued after abandoning ship prior to the 23d. The vessel had been aground on a reef 40 mi east of Belize since the 9th. The ship started breaking up in heavy seas while salvage operations were proceeding. The Cypriot VARIA (613 tons) ran aground at Tocra in the Mediterranean Sea about the 22d after developing steering trouble in rough seas. The 500-ton German ELBE sank in heavy seas off the Netherlands on the 26th. All crew were rescued but one. The 1,599-ton Swedish SKAGERN and the 7,786-ton Finnish roll-on/roll-off FINNSAILOR collided in heavy fog at Gothenberg on the 29th. The SKAGERN sank. Seven of the 10 crewmen were rescued. The 1,744-ton SEEADLER of East German registry sank after a collision in heavy fog with the 4,262-ton Russian roll-on/roll-off INZHENER NECHIPORENKO off the Russian Baltic coast. All of the crew were rescued. The 30,280-ton Indian cargo vessel JALAVIJAYA from New Orleans was at Balboa on the 28th with hull damage from contact with a quay wall in prevailing swells.

SMOOTH LOG, APRIL 1978--The paths of the storm centers were clustered in the vicinity of Newfoundland. They passed over or near the island in almost every direction, except south. The most-traveled path was from the northern Midwest, across the Great Lakes to New Brunswick, and then from Newfoundland to east of Kap Farvel. There was one lucky location near Quebec where the paths of four storms crossed. There were fewer storms than normal along the U.S. East Coast. Three storms wandered over Scandinavia. There were several storms that approached the west coast of Europe with only two centers penetrating any distance inland. Four storms influenced the central Mediterranean Sea.

The concentration of storm paths near Newfoundland was reflected in the monthly mean-pressure pattern. The Icelandic Low was shifted from east of Kap Farvel to two 1007-mb centers, one near Trinity Bay, Newfoundland, and the other near 50°N, 47°W. This was only 1 mb deeper than the climatic mean. The Azores High was 1024 mb near 30°N, 28°W, a few miles east of its climatic normal 1021-mb center.

There were two significant anomaly centers. A negative 5 mb was just south of St. Pierre Island, and a positive 11-mb center was slightly east of Iceland.

In the upper air there was an anomalous LOW over Belle Isle with a pronounced ridge over Iceland and west of the United Kingdom.

Extratropical Cyclones--This first storm of the month moved eastward out of the northern Plains States. At 1200 on the 2d the 990-mb center was over Cape Breton Island. The AMERICAN ARCHER was near 39°N, 63°W, ahead of the cold front with southerly 40-kn winds and 25-ft swells. A ship with the call letters YNTF reported howling 70-kn winds at the cold front near 38°N, 70°W. Six hours later the GENERAL STANISLAW POPLAW was pounded by 30-ft seas and swells about 400 mi south of St. John's. On the 3d the winds were generally 40 to 50 kn, but the ATLANTIC CINDERELLA found 70-kn winds just ahead of the trough behind the front. Ships were reporting 20- to 26-ft waves. At 1200 on the 4th the storm was over the southern tip of Greenland and doomed.

This storm formed late on the 3d as a frontal wave on the front trailing from the storm above. It raced north-northeastward and continued to pull cold air southward. The winds west of the front were generally gales and the swell was from the northwest at 10 to 15 ft. East of the front the winds were a little stronger. The HENRI POINCARE (42°N, 37°W) had 50-kn winds from the southeast. Near 45°N, 38°W, the ATLANTIC CROWN was carrying 44-kn winds and 25-ft swells. A ship far to the south near 33°N, 43°W, also was grappling with 25-ft swells at 1200 on the 4th.

This LOW, now at 984 mb, was slightly east of Kap Farvel at 1200 on the 5th. The strongest winds were 40 kn or less with occasional 20-ft waves. The storm drifted up the Greenland coast and disappeared in the Denmark Strait on the 8th.

A low center developed off Norfolk on the 7th. It moved northeastward and turned northward and then westward on the 9th. The AMERICAN LEGEND had 45-kn winds and 21-ft seas and swells slapping her starboard side near the occlusion on the 8th. As this LOW languished over Newfoundland on the 10th, several small LOWs spun out of the trough south of the LOW. A 1036-mb HIGH was moving southeastward from Greenland and blocking eastward movement of the front and these LOWs. The HIGH was pushing relentlessly southward as the LOWs wore themselves out against its western edge. The gradient tightened between the front and the HIGH. The AKADEMIK FILATOV (41°N, 36°W) was sailing northeastward east of the front with 50-kn winds and 23-ft waves. On the 13th a SHIP at the front was sailing eastward with 36-ft swells on her stern. By the 13th another LOW was moving northeastward from the East Coast and changed the orientation of the gradient as the HIGH moved southeastward.

This LOW came out of the high plains of Canada west of Lake Winnipeg. Its center moved off the coast over Nova Scotia on the 14th. Another LOW was paving its way. The AMERICAN ARCHER was east of this LOW with 62-kn southeasterly winds. The westerly circulation south of the centers extended nearly coast to coast.

At 1200 on the 15th the LOW of interest was 976 mb near 45°N, 47°W. The EXPORT DIPLOMAT near 36.5°N, 55°W, had 45-kn winds and 23-ft waves. The HANS SACHS was at 39°N, 44°W, at 1800 with 60-kn westerlies and 33-ft seas. On the 16th there was only one 968-mb LOW near 52°N, 34°W. The AMERICAN ARCHER was near 46°N, 39°W (about 400 mi southwest of the center) and stationary with 50-kn westerly winds, 20-ft seas, and 49-ft swells. At 1800 the observation was the same, except the wind and swell direction backed 10 degrees. The SUGAR CRYSTAL was about 10° longitude farther east with 30-ft swells, which continued into the 17th. The LOW had now turned northwestward. Two ships between Iceland and Scotland both reported 58-kn southeasterly winds. As the LOW approached Kap Farvel on the 18th, it broke away from the upper air circulation and again moved eastward to dissipate south of Iceland.

As the above LOW moved northward, high pressure was moving southeastward out of Canada. On the 18th the HIGH split into multiple centers creating a large area of flat gradient off the East Coast. Cyclonic circulation developed between three HIGH centers on the 18th. This LOW was very clearly defined by the wind and pressure reports of three ships almost evenly spaced around the inceptive center. By the 19th it had formed a concentrated circulation, and a ship reported 40-kn northeasterlies. At this time another center formed east of the first. Several ships were reporting gale-force winds. On the 20th a ship northeast of the center had 20-ft waves, as did another southwest of the center. The EXPORT FREEDOM was north of the center with 45-kn winds from the north-northeast and northeasterly 25-ft swells.

On the 21st the LOW was 990 mb near 46°N, 31°W. The ORBITA was not far away with 60-kn westerly winds. The EXPORT PATRIOT had 45-kn winds and 15-ft waves pounding her beam as she sailed toward the English Channel. OWS Romeo recorded 20-ft waves which increased to 23 ft by the 22d. At that time the LOW stalled near 55°N, 23°W, for 18 hr before turning southward then southeastward to dissipate over the Bay of Biscay on the 27th.

This East Coast LOW formed on the 20th at the point of occlusion of a frontal system moving eastward out of the Midwest. There was an isolated 40-kn wind report that afternoon. By 1200 on the 21st the 992-mb storm was slightly north of Maine. An English ship was sailing toward New York with southerly 40-kn winds and 26-ft swells hitting her port side. The MORMACSTAR was also heading toward New York at 37.5°N, 63°W, with 45-kn winds and 16-ft waves.

On the 22d another LOW formed off Cape Hatteras. At 1200 the ROMANTIC was southwest of the center near 37°N, 70°W, and radioed winds of 98 kn. This seemed high, but 6 hr later the ALBATROS 4 also sent a report of 80-kn winds from near 41°N, 66°W, with 16-ft seas and 43-ft swells. Their relationship to the storm's center was very near the same.

On the 23d the second LOW became the primary storm. The storm center moved over Newfoundland on the 24th. The EXPORT BAY was sailing with 23-ft swells on her stern on the 25th. The ROBERT E. LEE (40°N, 60°W) was north of the Mason-Dixon Line with 58-kn northwesterly winds. Late that day the LOW disappeared and another formed nearby and moved toward the Labrador Sea to fade away.

Monster of the Month--This storm traveled southeastward out of the northern plains. As it crossed the Carolinas on the 26th, it dumped heavy rain over a large area of the central East Coast. Gale warnings were in effect from Cape Hatteras northward, and tides were expected to be 1 to 2 ft above normal and cause

Figure 48.--This part of a house toppled onto the beach as a result of erosion in the Virginia Beach, Va., area. Wide World Photo.

additional beach erosion. By late on the 26th the storm had produced 1 to 3 in of rain in many areas, with 4 to 6 in in parts of North Carolina. Rivers were flooding. In the Norfolk area, the winds gusted to 48 kn and to 60 kn in Hampton, Va. High tides and surf were 3 ft above normal, with flooding causing much erosion (fig. 48). Over 6 in of rain fell in the Roanoke, Va., area and up to 21 in of snow fell in the southwestern mountains. A barge on the Chesapeake Bay broke its moorings and crashed into the Pamunkey River bridge knocking out two pilings.

The 0000 chart of the 27th showed the storm over Cape Hatteras at 998 mb. At that time the CHEVRON ARNHEM was off Norfolk with 58-kn winds out of the east and 30-ft seas. Six hours earlier the winds had been 44 kn and the seas 26 ft. At 1800 the SAN JUAN was west of the center with 45-kn gales and 20-ft seas. The high tide at Sewells Point, Va., was the highest ever, except for during tropical storms and the Ash Wednesday storm of March 1962. To add to this, the continued northerly flow behind this storm brought record low temperatures for May 1 to the Northeast from the Great Lakes to Maryland.

At 0000 on the 28th the 990-mb LOW was near 38°N, 71°W. The SANTA LUCIA was 180 mi due west of the center. The northerly winds were 50 kn with 20-ft seas, but the swells were a towering 41 ft. The MARIA U was only 4 mb west of the center with 63-kn winds and waves of 30 ft. Twenty-four hours later at 0000 on the 29th, the storm was 980 mb. The LEON PIERRE had 45-kn winds and 25-ft waves slightly over 300 mi south of the center. At 1200 the BEN OCEAN LANCER at 43°N, 62°W, within 10 mb of the center had 45-kn northerly winds, 25-ft seas, and 30-ft swells. Many of the wind reports were running in the gale category, but the sea reports of 20 ft or greater were increasing south of the center as the fetch increased.

The storm center moved over Cape Race on the 30th. A reporter called VC94 had 61-kn southerly winds in the vicinity of 47°N, 46°W. Far to the south a ship had 26-ft swell waves. Late on the 30th another LOW formed over the Gaspe Peninsula to the west. Within 12 hr the original LOW had disappeared.

Casualties--The 19,664-ton FEDERAL THAMES and the 6,017-ton CABOT collided during a snow storm on the 1st about 20 mi upriver from Quebec City. The 13,203-ton SATURN had tank damage due to ice pressure in Lake Michigan. The 76,088-ton THALASSINI DOXA put into Gibraltar on the 9th because of reported ice damage. The 35,302-ton bulkcarrier HOPECLIPPER arrived Leningrad behind an icebreaker convoy with a cracked bow. The 16,023-ton ROSELINE collided with the 12,680-ton ELENI V on the 6th. The ELENI V was cut in half in fog with 1 mi visibility. All crewmembers were safe.

The 5,924-ton ARSENE SIMARD was in dyydock on the 14th at Lauzon, Quebec, with ice damage. The sistership JOS. SIMARD (5,102 tons) was at Montreal with ice damage the same day. The platform ORION onboard pontoon FEDERAL 400-5 from Cherbourg to Recife was hove-to for 5 hr in southerly winds of force 8/9 (gale to strong gale) with rough seas and heavy swells. The Greek-registered RIO D'ORO (2,140 tons) and the Polish IWONICZ ZDROJ collided in dense fog off the Netherlands on the 23d.

An iceberg 36 times the area of Bermuda and inhabited by penguins is drifting slowly in the South Atlantic from Antarctica in the direction of Africa. It measures 32 by 24 mi with a draft of at least 600 ft. The first week of May it was about 200 mi northwest of South Georgia Island. See article on page 328.

# Smooth Log, North Pacific Weather

## March and April 1978

SMOOTH LOG, MARCH 1978--The storm centers in the western ocean closely followed the climatological paths, but they were not so consistent in the eastern half. There was a primary path toward the east-northeast from along the south coast of Japan into the Bering Sea. A secondary part of that track became part of a primary track at midocean and extended into the Gulf of Alaska. This part was farther east than climatology indicates. A secondary climatological track from the southern Gulf northward to Alaska became a primary one with more travel. The storm path into the U.S. West Coast was farther south than normal.

The overall pressure pattern closely paralleled climatology. Normally, the Aleutian Low has two centers, but his month they were reversed. The deepest Low at 999 mb was in the Western Hemisphere near 51°N, 171°W. The deepest Low is normally in the Eastern Hemisphere. The secondary Low was 1000 mb southeast of Kamchatka. These were 8 mb and 5 mb lower than the mean, respectively. The Pacific High at 1021 mb near 30°N, 157°W, was 1 mb lower and about 800 mi west of its mean.

The primary anomaly was -11 mb at 50°N, 165°W. South of Kamchatka near 45°N, 160°E, there was a -8-mb and a -6-mb center off San Francisco near 37°N, 137°W. The most significant positive anomaly was 6 mb over Siberia north of Kamchatka.

In the upper air at 700 mb there were also double low centers with the anomalous one near Adak, Alaska. The normal center over the Sea of Okhotsk was southeast of the tip of Kamchatka. This resulted in a broader trough off the Asian coast. The anomalous Low resulted in a sharper trough off the North American west coast and ridge over the mountains.

Extratropical Cyclones--On the 2d, there were four LOWs and two HIGHs over the Pacific between latitudes 15°N and 60°N. On the 0000 chart of the 3d a new LOW had formed between Hawaii and the U. S. West Coast. The TENNESSEE MARU was about 150 mi southwest of the 984-mb center (37°N, 151°W) with 50-kn winds and 16-ft waves. Three hours previously she had reported 54 kn and 20-ft waves while

southeast of the center. At 0600 two ships reported 55-kn winds in the vicinity of 33°N, 148°W, the waves were 20 to 30 ft. The WORLD RUBY (33°N, 150°W) measured 60-kn winds and 30-ft waves for the 1200 observation. At 1800 a SHIP at 30°N, 144°W, fought 64-kn westerlies and 31-ft swells. On the 4th the storm's center was nearing the northern California coast with high waves and heavy rain along the coast. Up to 14 in of rain had fallen in the mountains of southern California in 3 days. Less than a week earlier over 8 in had fallen in some places in that area. Winds up to 50 kn were recorded along the coast and in the mountains. The EASTERN CITY was over 300 mi southwest of the center with 54-kn winds and 30-ft waves. On the 5th there were still ship reports of 20-ft waves, but by that evening the storm dissipated over northern California. (See the article, "The 1977-78 Southern California Winter," on page 317 of this issue.)

This was a slow-moving storm. It was also one that went for a long period with a double center. It formed on an occlusion over the Sea of Japan on the 3d and moved across the Tsugaru Strait early on the 4th. On the 5th the 990-mb storm was at 44°N, 153°E. The PRESIDENT MONROE was near 34°N, 148°E, slightly north of an incipient frontal wave with 55-kn northerly winds. On the 6th the JAPAN RAINBOW was north of the storm's center with 61-kn winds, as a second low center had formed at the point of occlusion. The GEORGIANNA twice reported winds over 50 kn on the 7th. The original LOW was moving eastward very slowly, while the eastern center picked up speed and was increasing the distance between the two centers. The FERNIE was 600 mi south of the center with 55-kn winds and 18-ft swells on the 8th. By the 9th the western LOW had deteriorated to only a trough, while the eastern center had raced into the Bering Sea to disappear on the 10th.

This LOW developed in the far south circulation of the LOW above as it filled over the Bering Sea on the 10th. A ship found 20-ft swells west of the center in the area where the fetch extended from the Bering Sea. The winds were only 20 kn. The storm deepened rapidly as it moved northward, and it was 959 mb near 48°N, 164°W, at 1200 on the 11th. On the 12th the storm crossed the Aleutian Islands. The MAKHTUMKULI at 53°N, 170°W, was battling 64-kn westerly winds. The KENRYU MARU (52°N, 167°W) contended with 50-kn winds, but reported 28-ft seas. The RHEIN MARU was 700 mi south near 43°N, 165°W, with 40-kn winds and 33-ft seas and swells. Ocean buoy 46003 reported 25-ft seas. On the 13th a ship whose call letters were obscured by the analysis reported 40-kn winds with 25-ft swells near 45°N, 176°W. The LOW was now dissipating as the center moved westward over the Bering Sea. The RHEIN MARU (43°N, 174°W) reported 33-ft swells on the 14th, as a secondary LOW kept the northwesterly circulation over the area.

This storm also began on the 10th, but over Japan. It formed south of and in the circulation of a LOW that came out of the Yellow Sea into the Sea of Japan. Three Soviet ships were near 37°N, 141°E, with 50- to 60-kn winds. The seas were up to 16 ft. On the 11th there was only the southern LOW as a center. The SEA-LAND TRADE was south of the LOW with 53-kn northwesterly winds, while the JAPAN RAINBOW was northeast of the center with 68-kn winds. The VAN ENTERPRISE was off the west coast of Honshu in the Sea of Japan with 54-kn winds and 33-ft seas. On the 12th a small LOW formed on the occlusion, and the GLADIOLUS found 58-kn westerly winds about 200 mi south of the center. The new center raced off to the east under the upper air zonal flow, and another center materialized south of the old center.

Late on the 16th a wave was analyzed on a weak stationary polar front. The storm was 1000 mb at 0000 on the 17th, and the EASTERN CITY had 58-kn winds near a trough line behind the front. Twenty-four hours later the pressure had plunged to 976 mb near 45°N, 178°W. The TAIZAN MARU was south of the center with 60-kn winds, and the EDEN MARU was to the north with 56 kn and 26-ft waves. By 1200 on the 19th the storm had moved to 55°N, 165°W. Three Japanese ships south of the center had 50- to 60-kn winds with 26- to 50-ft waves. The ASIA MARU reported 50-ft seas and 33-ft swells. Early on the 20th several ships had seas and/or swells to over 30 ft, but by late in the day the storm was rapidly deteriorating as it moved over land.

A col area existed over the Sea of Japan on the 18th, and late in the day a LOW developed south of the Islands. It quickly deepened over the Kuroshio Current and at 0000 on the 20th was 970 mb at 40°N, 153°E. The FEDSTEEL near 34°N, 148°E, reported 78-kn northwesterly winds and 23-ft seas and swells. Other ships were calling the winds more than 60 kn and the waves to 30 ft. At 0600 the KENRYU MARU (37°N, 150°E) had 50-kn winds, 33-ft seas, and 43-ft swells. There were also high waves (31 ft) east of the center and north of the occlusion. On the 21st the NEPTUNE RUBY was sailing eastward as the storm moved northward and twice reported winds over 50 kn and seas and swells of 23 ft. The SHUNWIND was in the northeast quadrant of the storm in the vicinity of 54°N, 170°E, on the 21st and 22d. She was measuring winds in only the gale and strong gale category, but the swells were running from 33 to 39 ft out of the southeast. This is not normally the quadrant of the storm that such high waves are found because of the rapid and radical changes in wind direction as the storm moves. The pressure was still about 970 mb, but it was losing its circulation to another LOW from south of Japan. On the 23d it was gone.

This was the storm that absorbed the one above. It formed over the East China Sea on the 20th. It raced eastward under the upper air flow bringing heavy rain to Japan and gales to shipping in the area. The storm was 972 mb near 42°N, 154°E, at 0000 on the 23d. The PACIFIC ARROW was south of the center with 50 kn and 20-ft waves. The VICTORIA CITY (43°N, 165°E) had 55-kn winds and 41-ft seas on her starboard bow. At 1200 an American ship was stationary near 51°N, 176°E, and reporting 66-ft swells. The height looked suspicious, but the pressure, wind, swell direction, and ship movement indicated it must be a good report. Many times interference during the retransmissions of these reports results in errors when they are finally plotted.

On the 24th and 25th the reported winds were generally in the gale category with an isolated swell report near 20 ft. The PRESIDENT JEFFERSON was the exception to this on the 25th and 26th. She was sailing southwestward during this time with a mean position of about 51°N, 169°E. She estimated the winds at 45 to 55 kn, the seas as 18 to 20 ft, and the swells as 33 to 48 ft. At that time the ship was about 200 to 300 mi southeast of the LOW, and the pressure ranged from 969 to 995 mb. The storm turned westward at this time and disappeared from the analysis on the 27th.

A trough that moved over Japan on the 25th became a LOW on the 26th. The LOW was 986 mb on the 28th. A ship had 50-kn winds, 26-ft seas, and 30-ft swells at 1200 while 300 mi southwest of the storm's center. The PRESIDENT TAFT found 33-ft waves 500 mi to the southeast of the center. On the 29th the maximum winds plotted were 45 kn, but two ships south of the storm reported 30-ft swells. The ANCO DUKE near 39°N, 180°, was headed westward into 25-ft seas and 35-ft swells. On the 30th a ship had 45-kn gales, 25-ft seas, and 33-ft swells in the westerly flow about 800 mi southwest of the center (51°N, 170°W). As the storm moved over the Gulf of Alaska on the 31st, it dissipated.

Another East China Sea storm. It formed on the 27th south of Korea. On the 28th there were two other small LOWs north of the Sea of Japan. By 1200 on the 29th this LOW had absorbed these and their cyclonic circulation. The storm was now 980 mb off Hokkaido. On the 30th a SHIP (38°N, 158°E) was sailing eastward with 45-kn northwesterlies and 31-ft swells from the west-northwest. On the 31st most of the winds around the storm were less than 30 kn, but there were isolated high-swell reports. A Japanese ship northwest of the center was sailing with 33-ft swells from the northeast on her stern, and the IRISH ELM south of the center had quartering 25-ft swells. On April 1 secondary LOWs on the periphery of the storm partially robbed it of its energy and violence and it disappeared by the 2d as one of these became the primary storm.

Casualties--The 35,677-ton British-registered EASTERN CITY requested survey of heavy weather damage alleged to have occurred on March 3 and 4. The Liberian-registered 11,169-ton GOLDEN EXPLORER was at Wakayama on the 13th and reported heavy weather damage on a voyage from the Columbia River to Kobe. At the same time the 9,954-ton SUN CHONG reported heavy weather damage during a trip from Los Angeles to Yokohama.

The 21,495-ton American PRESIDENT ROOSEVELT and the 2,990-ton Thai CHAMNARN SAMUT collided in heavy fog in Hong Kong Harbor on the night of March 27. The Thai freighter lost one crewman and another was injured. Both vessels were damaged. Within 24 hr two more ships collided in fog near Hong Kong, southeast of Wagland Island. The ships involved were the 2,625-ton Indonesian PAN ASIA SATU and the 4,000-ton Chinese RED FLAT 153. Neither ship was seriously damaged.

The 11,049-ton bulkcarrier PINE LIGHT enroute from Japan to Seattle sustained damage on the 31st from a big wave. Two 40-ft containers were lost overboard and approximately 10 were damaged.

SMOOTH LOG, APRIL 1978--The mean paths of the extratropical cyclone centers this month were close to a carbon copy of the climatological mean. The primary and most-traveled path extended from south of Kyushu to the Andreanof and Pribilof Islands. An eastward-oriented secondary path from the Tsugaru Strait joined this one. The storm centers over the Gulf of Alaska were not so clearly cut, as they tended to circle off Queen Charlotte Sound. Two lonely, widely separated storms formed to the north and west of the Hawaiian Islands. One moved to off the northern California coast, but did not cross it.

The climatic pressure pattern indicates multiple centers for both the Aleutian Low and the Pacific High. This month the mean only indicated one center in each. According to 1948 to 1970 climatological normals, the Aleutian Low has four 1009- to 1010-mb centers stretched east to west across the Bering Sea. This month the single center of circulation was 1002 mb near 55°N, 180°. The Pacific High usually has three centers of about 1022 mb, but this month they were replaced by one 1026-mb center near 37°N, 150°W.

The largest anomaly center was minus 8 mb near the Low center. A minus 6-mb center near 43°N, 168°E, reflected a sharper troughing action in the area. Southeast of Vancouver Island, a minus 3-mb anomaly center resulted from the cyclones circling in that area, thus extending the time that they affected it. The only significant positive anomaly was 4 mb, centered near 40°N north of Hawaii.

A closed Low over the Bering Sea replaced the normal trough at 700 mb. A sharp, short-wave trough and ridge paralleled the North American coast from Washington State northward. The inflection point was almost directly over the coast. The High was several meters higher than normal. This with the deeper closed Low produced a tighter gradient and higher upper air winds.

Typhoon Olive formed east of the Philippines in the third week of the month.

Extratropical Cyclones--On the first day of the month a LOW center was moving along the Aleutian Islands. A sharp trough extended southwestward, and two new centers formed in this trough. The northern one survived and at 1200 was near 38°N, 167°E. At that time the LOW turned sharply northward and quickly deepened with a large circulation. The JAPAN RAINBOW was west of the center with 50-kn winds and snow showers at 0000 on the 2d. South of the LOW near 38°N, the ANCO DUKE was sailing westward into 47-kn gales and 25-ft seas and swells. At 0600 the JAPAN RAINBOW reported 68-kn northwesterly winds near 48°N, 164°E. By 0000 on the 3d, the 958-mb center was crossing the 55th parallel near 173°E and turning eastward. A ship about 150 mi south of the center was tossed by 33-ft seas. The PRESIDENT MADISON and SEA-LAND COMMERCE were both involved with the storm with 40- to 45-kn winds. The STAR BULFORD about 250 mi southeast of the center had 60-kn winds and 26-ft seas. Winds of 40 to 50 kn and seas up to 30 ft continued into the 4th. The DON CARLOS (51°N, 171°E) took the honors with 36-ft seas. The

JAPAN RAINBOW was keeping pace with the storm, and early on the 4th her radio messages indicated 78- and 87-kn winds along 49°N. Late on the 4th the storm died over the cold Bering Sea.

In the meantime another storm was harassing ships off the coast of Japan. It formed on an extension of the front associated with the previous storm, near Okinawa. High wind and wave reports from this storm started on the 3d, while its center was only a few miles south and east of Tokyo. Over 20 ships reported winds of 40 kn or greater between 30° and 37°N and mostly between 140°E and 145°E. The highest wind was 66 kn near 36°N, 142°E, and the highest wave was 39 ft reported by the ORIENTAL EXECUTIVE near 35°N, 141°E. She had 50-kn winds. The high winds and waves continued through the 4th. The PRESIDENT VAN BUREN (35°N, 145°E) reported 33-ft seas with 60-kn winds out of the northwest. The KAKONE MARU (35°N, 152°W) was plowing into 33-ft swell waves.

On the 5th the winds were not quite so strong; but the waves, particularly the swell, persisted and increased. The NEPTUNE TOPAZ near 34°N, 161°E, was pounding into 39-ft swells. The JAPAN BEAR at 43°N, 178°W, and the PIONEER CRUSADER at 31°N, 160°E) both reported 41-ft waves. The LOW split into two centers on the 1200 analysis, and the northern one took over the circulation on the 6th. At 0000 both were 966 mb. The PRESIDENT ROOSEVELT was 1,000 mi to the south near 36°N, 176°E, with 23-ft seas. The storm was north of the Aleutians and traveling east-northeastward. On the 7th the HAKUZAN MARU was 200 mi south of the center with 45-kn southwesterlies and 33-ft swells. The center stalled for 24 hr over Bristol Bay on the 8th. Two ships and a buoy reported seas and swells from 20 to 28 ft south of the Alaska Peninsula. The storm moved over the Yukon River on the 10th and filled.

This storm originated far inland near Lake Baykal in the U.S.S.R. On the 6th it moved over the Sea of Japan--a well-developed storm. The WYOMING was sailing eastward with 18-ft waves slapping her starboard side. The stronger winds were in the southerly flow and at 1800 a ship was hit by 34-ft swells east of Hokkaido. Two ships reported 33-ft swells on the 7th. The BRANFF (38°N, 152°E) was south of the warm front and east of the cold front, and the other SHIP was west of the cold front near 33°N, 146°E. Most of the higher winds were in the gale category. As the storm crossed the Kurile Islands, it started to break up into multiple centers. On the 8th no principal center was evident.

The East China Sea provided this contribution to marine weather. This storm developed as a frontal wave off Shanghai on the 10th. There were a few gale reports on the 12th as the storm sailed eastward south of Tokyo. By 0000 on the 13th, it was 988 mb and consolidating its circulation. The TAKARA was northwest of the center with 50-kn winds and 30-ft seas and swells out of the east. A ship south of the center and slightly east of the front suffered with 25-ft swell waves. The storm continued slowly eastward and was 986 mb at 1200 on the 15th near 42°N, 167°E. The winds and waves were increasing. The AMERICAN LANCER (46°N, 173°E) found 68-kn southeasterly winds. The N.R. CRUMP was west of the center with 31-ft seas from the northwest. A ship in the southwest quadrant found 25-ft seas. The winds were in the 40- to 50-kn range. On the 16th the storm suddenly deteriorated to a trough as part of another LOW.

The valley of the Yellow River was the birthplace of this storm. It moved across Hokkaido on the 16th. There were a few wind reports in the 40-kn range as it crossed the Yellow Sea and the Sea of Japan. It raced to near 51°N, 164°E, by 1200 on the 17th. The ASIA GOLD found 50-kn winds near 45°N, 154°E, about 300 mi south of the storm's center.

At 0000 on the 18th the VAN WARRIOR (48°N, 171°E) was sailing into 60-kn westerlies with 30-ft seas and 41-ft swells. A SHIP near 162°E had 33-ft seas and swells. About this time the center moved ashore on eastern Siberia and almost disappeared. A small circulation managed to survive until the 22d.

The northern ocean was cut into many small LOWs for about a week before another large, strong cyclone developed. On the 26th several of these combined into one cyclone near 44°N, 162°E. At 0600 two ships near 44°N, 147°E, had northerly 58- and 60-kn winds. At 1200 the EHIME MARU and HIKAWA MARU near 41°N, 152°E, were riding dangerous 26- to 30-ft waves. On the 27th the winds continued in the 40- to 50-kn range with 20- to 30-ft waves.

On the 1200 analysis of the 27th, a LOW had formed at the point of occlusion and was speeding eastward. The ACT 1 was stationary near 41°N, 163°E, with 33-ft swells. The last significant wave report with this center was 21 ft. By the 29th it had dissipated. The new LOW moved into the Gulf of Alaska.

This LOW formed on the 29th as a frontal wave near 34°N, 180°, southeast of a large HIGH centered over the Kurile Islands. It raced northeastward into the Gulf of Alaska. At 0000 on May 1 a ship near 43°N, 153°W, found 20-ft swells. At 0600 a ship off Vancouver Island had 23-ft swells. Ocean Weather Station Papa measured 50-kn winds at 0900. At 1200 the ARCO ANCHORAGE near the 978-mb center had a pressure of 983 mb with 45-kn winds and 25-ft swells. At 1800 there were five reports of winds of 40 to 50 kn around the storm, mostly in the southeast quadrant. The seas that were reported were from 20 to 34 ft. At 0000 on the 2d, the ARCO ANCHORAGE was sailing southward with 41-ft swells pounding her starboard side. The winds were not particularly strong, but the waves remained at 20 to 30 ft. At midday the storm crossed the Alaska coast and circled westward to dissipate.

Tropical Cyclones, Western Pacific--Typhoon Olive began in a broken cluster of convective cells on the 17th, just west of Yap Island. Within 24 hr she was at tropical-storm strength on a west northwestward course. She intensified slowly during the next several days. On the 19th and 20th Olive moved through the central Philippines. The 718-ton ferry LEYTE was anchored in a shelter on the 20th when the port anchor chain broke. She ran aground and suffered heavy bottom damage. The 683-ton freighter DON FRANCISCO ran aground off Banton Island on

(Continued on page 366.)

## Principal Tracks of Centers of Cyclones at Sea Level, North Atlantic

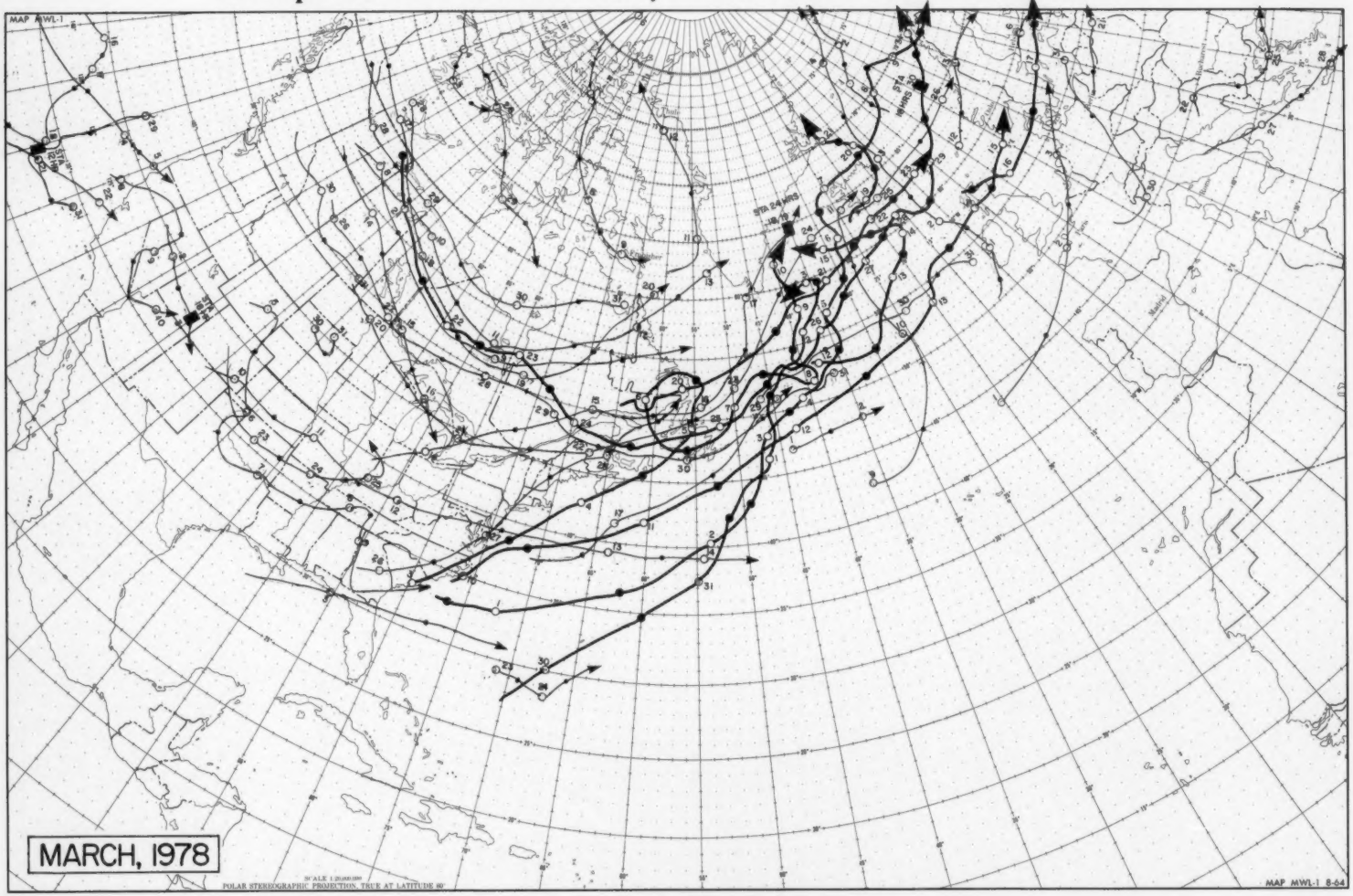



Figure 49.--Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

## Principal Tracks of Centers of Cyclones at Sea Level, North Atlantic

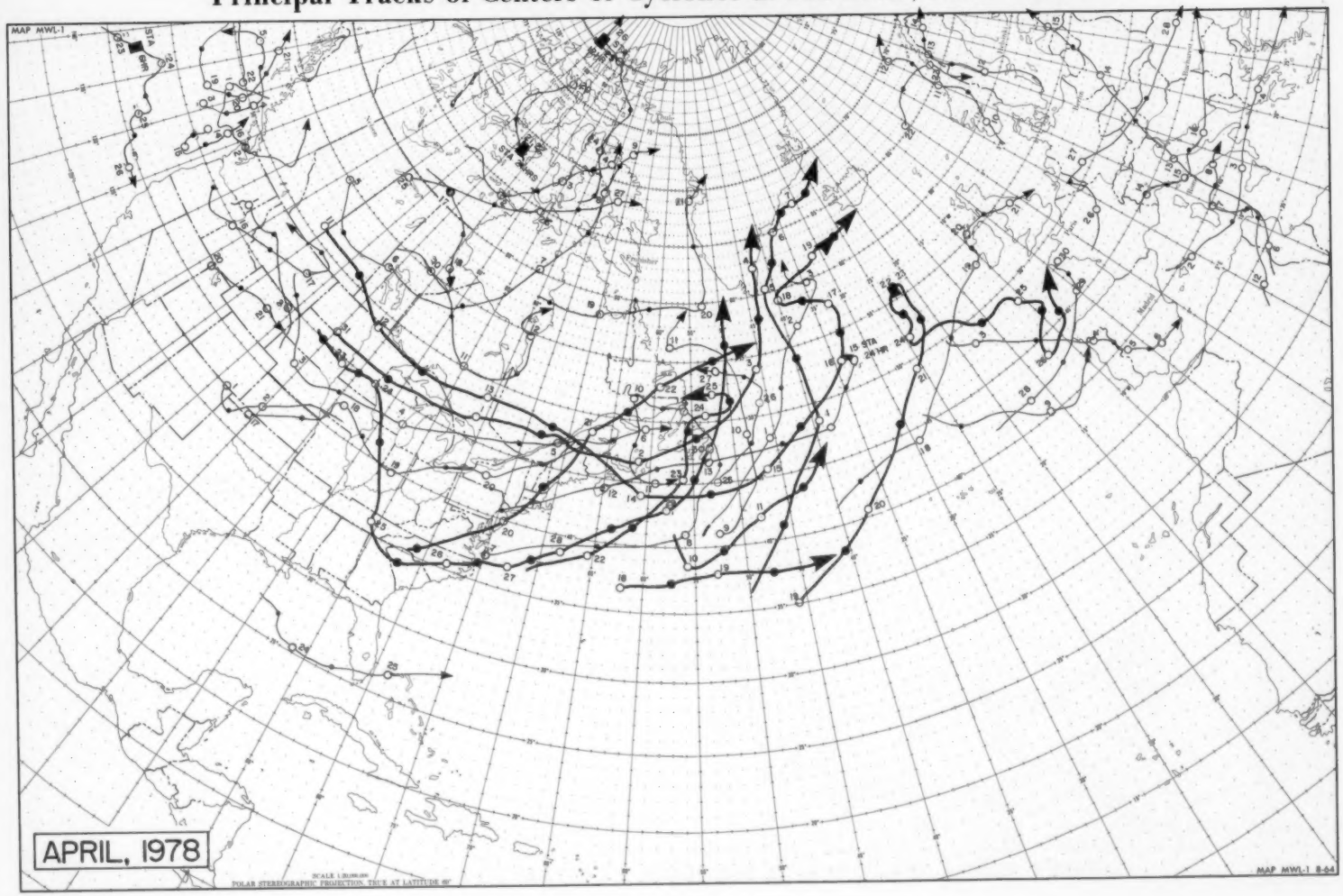



Figure 50.--Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

## Principal Tracks of Centers of Cyclones at Sea Level, North Pacific

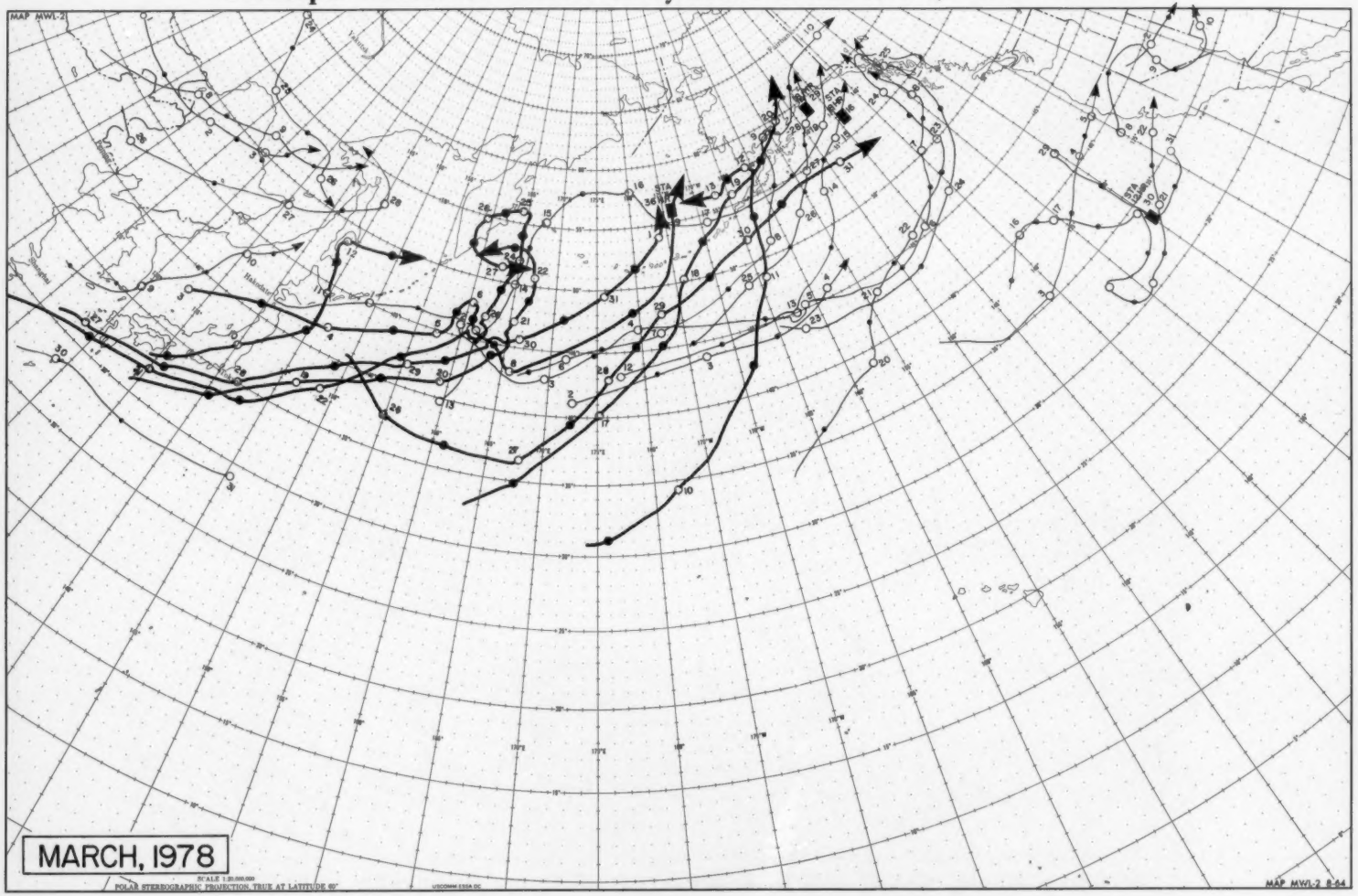



Figure 51.--Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

## Principal Tracks of Centers of Cyclones at Sea Level, North Pacific

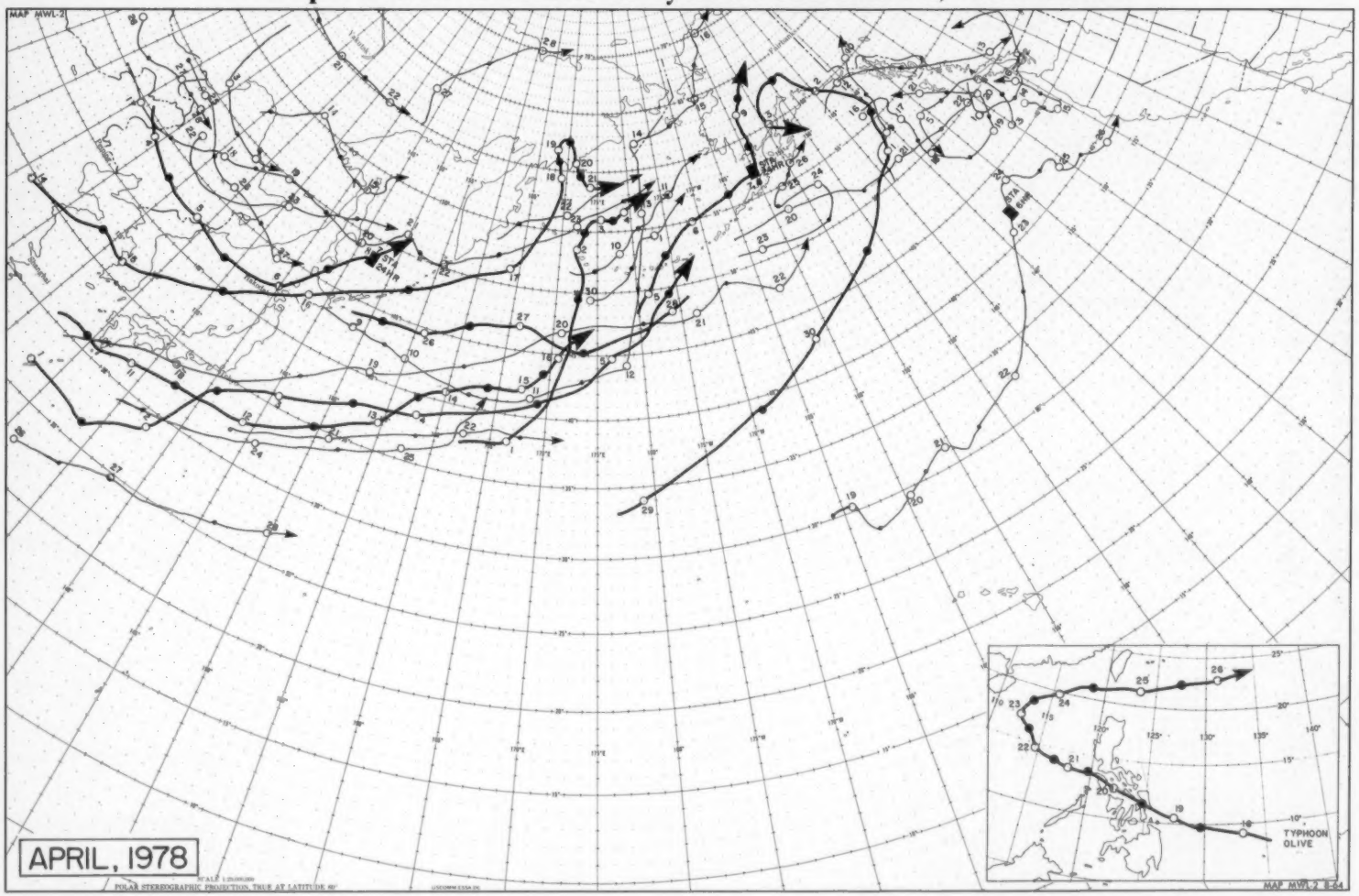



Figure 52.--Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

# Table 4
# U.S. Ocean Buoy Climatological Data
## March and April 1978

MARCH — DATA SUMMARY — 41002

AVERAGE LATITUDE 32.3N — AVERAGE LONGITUDE 079.5W

| MEANS AND EXTREMES | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | 09.2 | (09 00) | 17.0 | 21.9 | (22 18) | 244 | 31 |
| SEA TEMP (DEG C) | 19.8 | (07 08) | 21.4 | 23.7 | (04 21) | 244 | 31 |
| AIR-SEA TEMP (DEG C) | -13.2 | (19 00) | -04.4 | 02.7 | (17 08) | 244 | 31 |
| PRESSURE (MBAR) | 0998.1 | (05 21) | 1018.8 | 1033.8 | (18 15) | 244 | 31 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| SPEED (KNOTS) | 4- | 11- | 22- | 34- | TOTAL % | MEAN SPEED (KNOTS) | NO. OF OBS: 243 |
|---|---|---|---|---|---|---|---|
| DIR ↓ / → | <4 | 10 | 21 | 33 | 47 >47 | N | |
| N | 1.6 | 2.9 | 7.8 | 2.9 | | 14.9 | 15.6 |
| NE | | 1.6 | 2.1 | | | 7.1 | 10.8 |
| E | .4 | 5.7 | 2.5 | | | 8.6 | 12.7 |
| SE | | 1.2 | 4.5 | 3.3 | | 9.1 | 17.8 |
| S | | 2.1 | 12.3 | 4.1 | | 18.5 | 17.4 |
| SW | .4 | 2.9 | 9.9 | 5.4 | | 19.4 | 19.2 |
| W | .8 | 2.9 | 8.6 | 2.5 | 1.6 | 16.4 | 17.3 |
| NW | 1.2 | 5.3 | 7.4 | 5.9 | | 19.7 | 17.0 |
| CALM | .4 | | | | | .4 | 0 |
| TOTAL % | 4.9 | 20.2 | 48.1 | 25.1 | 1.6 | 100.0 | 18.3 |

MAX WIND SPEED: 37 KNOTS DIRECTION: 280 DEG DAY: 11 HOUR: 00

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 244

| HEIGHT (M) | <1 | 1-1.5 | 2-2.5 | 3-3.5 | 4-5.5 | 6-7.5 | 8-9.5 | >9.5 | MEAN | MAX | (DA HR) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % FREQUENCY | 5.3 | 54.1 | 32.4 | 6.8 | 1.2 | | | | 1.7M | 5.0M | (11 03) |

APRIL — DATA SUMMARY — 41002

AVERAGE LATITUDE 32.3N — AVERAGE LONGITUDE 079.5W

| MEANS AND EXTREMES | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | 15.6 | (29 08) | 19.3 | 22.8 | (09 21) | 235 | 30 |
| SEA TEMP (DEG C) | 19.8 | (05 08) | 21.9 | 23.0 | (08 21) | 236 | 30 |
| AIR-SEA TEMP (DEG C) | -08.1 | (28 00) | -02.2 | 01.8 | (30 21) | 235 | 30 |
| PRESSURE (MBAR) | 1000.3 | (27 09) | 1017.7 | 1031.5 | (04 03) | 235 | 30 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| SPEED (KNOTS) | 4- | 11- | 22- | 34- | TOTAL % | MEAN SPEED (KNOTS) | NO. OF OBS: 235 |
|---|---|---|---|---|---|---|---|
| DIR ↓ / → | <4 | 10 | 21 | 33 | 47 >47 | N | |
| N | | 1.3 | 2.1 | .8 | | 4.3 | 16.0 |
| NE | | 1.3 | 4.3 | 1.7 | | 7.2 | 14.8 |
| E | .4 | 4.3 | 3.8 | | | 8.5 | 10.4 |
| SE | .4 | 2.6 | 3.0 | | | 6.0 | 9.2 |
| S | 1.3 | 5.5 | 9.4 | 3.0 | .4 | 19.6 | 14.2 |
| SW | .9 | 3.0 | 17.9 | 4.7 | | 26.4 | 18.0 |
| W | .4 | 3.0 | 10.6 | 3.4 | | 17.4 | 18.1 |
| NW | | 2.6 | 8.0 | 2.1 | | 10.6 | 16.2 |
| CALM | | | | | | | 0 |
| TOTAL % | 3.4 | 25.4 | 57.0 | 15.7 | .4 | 100.0 | 16.8 |

MAX WIND SPEED: 45 KNOTS DIRECTION: 190 DEG DAY: 19 HOUR: 09

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 238

| HEIGHT (M) | <1 | 1-1.5 | 2-2.5 | 3-3.5 | 4-5.5 | 6-7.5 | 8-9.5 | >9.5 | MEAN | MAX | (DA HR) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % FREQUENCY | 18.5 | 52.1 | 25.0 | 4.4 | | | | | 1.4M | 3.5M | (20 06) |

MARCH — DATA SUMMARY — 42002

AVERAGE LATITUDE 28.0N — AVERAGE LONGITUDE 083.9W

| MEANS AND EXTREMES | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | 12.4 | (05 00) | 18.7 | 21.9 | (13 18) | 248 | 31 |
| SEA TEMP (DEG C) | 19.1 | (10 15) | 20.2 | 22.9 | (31 21) | 248 | 31 |
| AIR-SEA TEMP (DEG C) | -07.3 | (05 00) | -01.5 | 03.5 | (13 18) | 248 | 31 |
| PRESSURE (MBAR) | 1003.0 | (13 21) | 1017.5 | 1033.7 | (17 15) | 248 | 31 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| SPEED (KNOTS) | 4- | 11- | 22- | 34- | TOTAL % | MEAN SPEED (KNOTS) | NO. OF OBS: 248 |
|---|---|---|---|---|---|---|---|
| DIR ↓ / → | <4 | 10 | 21 | 33 | 47 >47 | N | |
| N | 1.2 | 5.2 | 17.3 | .4 | | 24.2 | 13.0 |
| NE | 1.2 | 8.1 | 1.6 | | | 10.9 | 8.9 |
| E | 2.4 | 15.7 | 9.3 | | | 27.4 | 8.2 |
| SE | 1.0 | 5.6 | 10.1 | .4 | | 17.1 | 12.6 |
| S | | 1.6 | 2.8 | .8 | | 5.2 | 15.9 |
| SW | .8 | .4 | | | | 1.2 | 5.7 |
| W | .4 | .4 | 2.0 | | | 2.8 | 12.9 |
| NW | .8 | 2.8 | 3.6 | | | 7.3 | 11.3 |
| CALM | 1.2 | | | | | 1.2 | .0 |
| TOTAL % | 9.3 | 39.8 | 48.2 | 1.6 | | 100.0 | 10.8 |

MAX WIND SPEED: 26 KNOTS DIRECTION: 010 DEG DAY: 18 HOUR: 12

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 248

| HEIGHT (M) | <1 | 1-1.5 | 2-2.5 | 3-3.5 | 4-5.5 | 6-7.5 | 8-9.5 | >9.5 | MEAN | MAX | (DA HR) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % FREQUENCY | 22.2 | 57.3 | 19.0 | 1.6 | | | | | 1.2M | 3.9M | (16 18) |

APRIL — DATA SUMMARY — 42002

AVERAGE LATITUDE 26.0N — AVERAGE LONGITUDE 083.5W

| MEANS AND EXTREMES | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | 18.1 | (27 09) | 21.7 | 24.1 | (18 21) | 234 | 30 |
| SEA TEMP (DEG C) | 20.0 | (01 12) | 22.1 | 24.5 | (19 21) | 234 | 30 |
| AIR-SEA TEMP (DEG C) | -03.6 | (27 09) | -00.3 | 01.0 | (03 15) | 234 | 30 |
| PRESSURE (MBAR) | 1004.1 | (30 21) | 1019.1 | 1032.4 | (04 18) | 234 | 30 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| SPEED (KNOTS) | 4- | 11- | 22- | 34- | TOTAL % | MEAN SPEED (KNOTS) | NO. OF OBS: 234 |
|---|---|---|---|---|---|---|---|
| DIR ↓ / → | <4 | 10 | 21 | 33 | 47 >47 | N | |
| N | | 4.7 | 6.4 | | | 11.1 | 11.7 |
| NE | .4 | 4.3 | 8.1 | .4 | | 13.2 | 11.3 |
| E | | 14.5 | 10.3 | | | 24.8 | 9.9 |
| SE | .4 | 11.6 | 33.3 | | | 45.4 | 12.0 |
| S | | 2.6 | .4 | | | 3.0 | 6.6 |
| SW | .4 | .4 | | | | .9 | 3.5 |
| W | .4 | | | | | .4 | 3.0 |
| NW | | | .9 | | | .9 | 12.5 |
| CALM | | | | | | .0 | .0 |
| TOTAL % | 2.1 | 38.0 | 59.4 | .4 | | 100.0 | 11.1 |

MAX WIND SPEED: 22 KNOTS DIRECTION: 030 DEG DAY: 22 HOUR: 21

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 227

| HEIGHT (M) | <1 | 1-1.5 | 2-2.5 | 3-3.5 | 4-5.5 | 6-7.5 | 8-9.5 | >9.5 | MEAN | MAX | (DA HR) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % FREQUENCY | 20.7 | 73.1 | 6.2 | .4 | | | | | 1.1M | 3.0M | (11 21) |

MARCH — DATA SUMMARY — 42003

AVERAGE LATITUDE 28.0N — AVERAGE LONGITUDE 089.0W

| MEANS AND EXTREMES | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | 14.2 | (05 08) | 21.1 | 25.0 | (16 15) | 248 | 31 |
| SEA TEMP (DEG C) | 22.5 | (10 12) | 23.6 | 25.0 | (31 21) | 248 | 31 |
| AIR-SEA TEMP (DEG C) | -11.0 | (05 08) | -03.0 | 00.6 | (18 15) | 248 | 31 |
| PRESSURE (MBAR) | 1004.3 | (03 12) | 1017.7 | 1031.5 | (18 15) | 248 | 31 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| SPEED (KNOTS) | 4- | 11- | 22- | 34- | TOTAL % | MEAN SPEED (KNOTS) | NO. OF OBS: 244 |
|---|---|---|---|---|---|---|---|
| DIR ↓ / → | <4 | 10 | 21 | 33 | 47 >47 | N | |
| N | .4 | 10.2 | 9.8 | 1.6 | | 22.1 | 11.9 |
| NE | .8 | 6.1 | 4.5 | | | 11.5 | 10.2 |
| E | .8 | 8.6 | 4.9 | | | 14.7 | 10.0 |
| SE | .4 | 3.7 | 8.2 | | | 12.3 | 13.2 |
| S | | 1.1 | 1.2 | .4 | | 2.7 | 15.0 |
| SW | | 1.2 | 1.2 | .4 | | 2.8 | 13.6 |
| W | .4 | | .8 | 1.6 | | 2.8 | 16.9 |
| NW | | 1.2 | 7.4 | 1.2 | | 10.0 | 14.1 |
| CALM | .4 | | | | | .4 | .0 |
| TOTAL % | 3.3 | 38.1 | 53.3 | 5.3 | | 100.0 | 12.2 |

MAX WIND SPEED: 24 KNOTS DIRECTION: 180 DEG DAY: 03 HOUR: 08

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 239

| HEIGHT (M) | <1 | 1-1.5 | 2-2.5 | 3-3.5 | 4-5.5 | 6-7.5 | 8-9.5 | >9.5 | MEAN | MAX | (DA HR) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % FREQUENCY | 24.3 | 52.3 | 20.9 | 2.5 | | | | | 1.3M | 3.6M | (03 18) |

APRIL — DATA SUMMARY — 42003

AVERAGE LATITUDE 28.0N — AVERAGE LONGITUDE 088.0W

| MEANS AND EXTREMES | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | 19.3 | (25 18) | 23.5 | 26.7 | (18 21) | 234 | 30 |
| SEA TEMP (DEG C) | 22.5 | (02 12) | 25.0 | 26.5 | (12 00) | 233 | 30 |
| AIR-SEA TEMP (DEG C) | -03.8 | (23 18) | -01.9 | 02.2 | (12 06) | 233 | 30 |
| PRESSURE (MBAR) | 1010.0 | (28 09) | 1018.1 | 1025.3 | (04 15) | 234 | 30 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| SPEED (KNOTS) | 4- | 11- | 22- | 34- | TOTAL % | MEAN SPEED (KNOTS) | NO. OF OBS: 234 |
|---|---|---|---|---|---|---|---|
| DIR ↓ / → | <4 | 10 | 21 | 33 | 47 >47 | N | |
| N | | 3.4 | 5.6 | | | 9.0 | 12.2 |
| NE | | 1.7 | 8.4 | | | 13.7 | 10.5 |
| E | .4 | 22.6 | 18.8 | | | 41.8 | 10.5 |
| SE | | 8.5 | 15.4 | | | 23.9 | 11.6 |
| S | .4 | .9 | 5.1 | | | 6.0 | 13.4 |
| SW | .4 | | 1.3 | | | 1.7 | 10.8 |
| W | | | 1.3 | | | 1.3 | 12.7 |
| NW | | .4 | 2.1 | | | 2.6 | 15.0 |
| CALM | | | | | | .0 | .0 |
| TOTAL % | 1.3 | 43.2 | 55.6 | | | 100.0 | 11.2 |

MAX WIND SPEED: 21 KNOTS DIRECTION: 170 DEG DAY: 13 HOUR: 08

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 228

| HEIGHT (M) | <1 | 1-1.5 | 2-2.5 | 3-3.5 | 4-5.5 | 6-7.5 | 8-9.5 | >9.5 | MEAN | MAX | (DA HR) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % FREQUENCY | 24.1 | 64.5 | 10.1 | 1.3 | | | | | 1.1M | 3.0M | (24 00) |

MARCH — DATA SUMMARY — 44002

AVERAGE LATITUDE 40.1N — AVERAGE LONGITUDE 073.0W

| MEANS AND EXTREMES | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | 00.8 | (25 18) | 09.2 | 18.9 | (22 06) | 248 | 31 |
| SEA TEMP (DEG C) | 03.8 | (25 08) | 04.3 | 05.3 | (28 21) | 90 | 11 |
| AIR-SEA TEMP (DEG C) | -03.4 | (28 18) | 00.8 | 04.4 | (22 03) | 90 | 11 |
| PRESSURE (MBAR) | 1004.3 | (27 15) | 1018.2 | 1034.6 | (25 18) | 88 | 11 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| SPEED (KNOTS) | 4- | 11- | 22- | 34- | TOTAL % | MEAN SPEED (KNOTS) | NO. OF OBS: 88 |
|---|---|---|---|---|---|---|---|
| DIR ↓ / → | <4 | 10 | 21 | 33 | 47 >47 | N | |
| N | | 2.8 | 13.2 | | | 16.0 | 14.4 |
| NE | | 1.5 | 2.8 | | | 4.4 | 12.3 |
| E | | | 8.8 | 4.4 | | 13.2 | 18.0 |
| SE | | 1.5 | 9.6 | | | 11.0 | 16.4 |
| S | | 2.9 | 16.2 | 1.5 | | 20.6 | 15.4 |
| SW | | 7.4 | 10.3 | | | 17.6 | 12.2 |
| W | | 5.8 | 10.3 | | | 16.2 | 11.8 |
| NW | | 2.9 | 4.4 | | | 7.4 | 9.4 |
| CALM | | | | | | .0 | .0 |
| TOTAL % | | 25.0 | 69.1 | 5.8 | | 100.0 | 13.6 |

APRIL — DATA SUMMARY — 44002

AVERAGE LATITUDE 40.1N — AVERAGE LONGITUDE 073.0W

| MEANS AND EXTREMES | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | 00.8 | (05 15) | 08.4 | 18.1 | (02 00) | 208 | 30 |
| SEA TEMP (DEG C) | 04.3 | (02 12) | 05.7 | 08.0 | (25 18) | 208 | 30 |
| AIR-SEA TEMP (DEG C) | -03.1 | (28 18) | 00.7 | 04.5 | (02 00) | 207 | 30 |
| PRESSURE (MBAR) | 0994.8 | (30 12) | 1014.4 | 1035.4 | (03 15) | 208 | 30 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| SPEED (KNOTS) | 4- | 11- | 22- | 34- | TOTAL % | MEAN SPEED (KNOTS) | NO. OF OBS: 176 |
|---|---|---|---|---|---|---|---|
| DIR ↓ / → | <4 | 10 | 21 | 33 | 47 >47 | N | |
| N | | .6 | 4.0 | .6 | | 5.1 | 18.4 |
| NE | | 2.8 | 3.4 | .6 | | 6.8 | 12.8 |
| E | 1.1 | | 5.7 | | | 6.8 | 8.5 |
| SE | | 5.0 | 2.8 | | | 9.7 | 9.2 |
| S | | 9.1 | 9.1 | .6 | | 18.8 | 10.6 |
| SW | | 1.7 | 9.7 | .6 | | 12.0 | 12.3 |
| W | 1.1 | 9.0 | 11.9 | | | 21.0 | 11.3 |
| NW | .6 | 4.5 | 8.5 | | | 13.5 | 12.3 |
| CALM | | | | | | .0 | .0 |
| TOTAL % | 2.8 | 43.8 | 51.1 | 2.3 | | 100.0 | 11.3 |

MAX WIND SPEED: 29 KNOTS DIRECTION: 010 DEG DAY: 28 HOUR: 03

MARCH — DATA SUMMARY — 44004

AVERAGE LATITUDE 38.0N — AVERAGE LONGITUDE 070.0W

| MEANS AND EXTREMES | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | -04.0 | (05 18) | 05.5 | 15.4 | (22 06) | 248 | 31 |
| SEA TEMP (DEG C) | 04.3 | (30 12) | 08.0 | 15.1 | (10 18) | 247 | 31 |
| AIR-SEA TEMP (DEG C) | -13.3 | (02 18) | -02.5 | 07.7 | (19 18) | 247 | 31 |
| PRESSURE (MBAR) | 0987.5 | (04 09) | 1016.8 | 1033.0 | (29 18) | 247 | 31 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| SPEED (KNOTS) | 4- | 11- | 22- | 34- | TOTAL % | MEAN SPEED (KNOTS) | NO. OF OBS: 247 |
|---|---|---|---|---|---|---|---|
| DIR ↓ / → | <4 | 10 | 21 | 33 | 47 >47 | N | |
| N | .4 | 1.6 | 7.3 | 2.4 | | 11.7 | 15.6 |
| NE | | 3.0 | 8.5 | 4.0 | | 15.4 | 16.9 |
| E | | 2.4 | 8.5 | 2.0 | | 13.0 | 16.9 |
| SE | 1.2 | .8 | 3.2 | 1.6 | | 6.9 | 15.4 |
| S | .8 | 2.4 | 4.0 | 2.4 | | 9.7 | 15.9 |
| SW | .4 | 3.2 | .4 | .8 | 1.2 | 6.0 | 16.5 |
| W | | 3.6 | 9.1 | 3.6 | | 16.4 | 16.2 |
| NW | .4 | 1.6 | 7.3 | 11.3 | | 20.6 | 20.7 |
| CALM | .8 | | | | | .8 | .0 |
| TOTAL % | 4.0 | 18.0 | 47.8 | 28.3 | 1.2 | 100.0 | 18.6 |

MAX WIND SPEED: 37 KNOTS DIRECTION: 230 DEG DAY: 19 HOUR: 18

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 100

| HEIGHT (M) | <1 | 1-1.5 | 2-2.5 | 3-3.5 | 4-5.5 | 6-7.5 | 8-9.5 | >9.5 | MEAN | MAX | (DA HR) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % FREQUENCY | | 7.0 | 40.0 | 35.0 | 8.0 | 1.0 | | | 2.7M | 6.0M | (20 00) |

% OF OBS WITH POTENTIAL SUPERSTRUCTURE ICING: MODERATE: 1.6% SEVERE: NONE OBS: 248

APRIL — DATA SUMMARY — 44004

AVERAGE LATITUDE 38.0N — AVERAGE LONGITUDE 070.0W

| MEANS AND EXTREMES | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | 01.0 | (03 21) | 07.7 | 19.8 | (30 09) | 238 | 30 |
| SEA TEMP (DEG C) | 04.7 | (01 08) | 08.6 | 15.3 | (27 00) | 239 | 30 |
| AIR-SEA TEMP (DEG C) | -10.3 | (29 18) | -00.8 | 07.3 | (02 06) | 234 | 30 |
| PRESSURE (MBAR) | 0982.6 | (28 18) | 1013.6 | 1035.2 | (03 15) | 237 | 30 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| SPEED (KNOTS) | 4- | 11- | 22- | 34- | TOTAL % | MEAN SPEED (KNOTS) | NO. OF OBS: 237 |
|---|---|---|---|---|---|---|---|
| DIR ↓ / → | <4 | 10 | 21 | 33 | 47 >47 | N | |
| N | | 1.7 | 7.2 | .8 | 2.1 | 11.8 | 19.7 |
| NE | | 3.8 | 6.8 | 2.5 | 3.4 | 16.5 | 20.8 |
| E | .4 | 1.7 | 5.4 | | | 5.5 | 10.7 |
| SE | | 2.1 | 10.1 | 1.3 | .4 | 13.9 | 16.8 |
| S | | .8 | 5.5 | 1.7 | | 8.0 | 16.8 |
| SW | .8 | 3.4 | 7.2 | 2.1 | | 13.5 | 14.2 |
| W | | 8.3 | 16.0 | 2.1 | | 26.5 | 14.8 |
| NW | | .8 | 12.2 | 2.1 | | 15.2 | 17.5 |
| CALM | | | | | | .0 | .0 |
| TOTAL % | 1.3 | 30.7 | 80.6 | 12.7 | 5.8 | 100.0 | 15.7 |

MAX WIND SPEED: 46 KNOTS DIRECTION: 030 DEG DAY: 28 HOUR: 00

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 0

| HEIGHT (M) | <1 | 1-1.5 | 2-2.5 | 3-3.5 | 4-5.5 | 6-7.5 | 8-9.5 | >9.5 | MEAN | MAX | (DA HR) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % FREQUENCY | | | 11.1 | 55.6 | 33.3 | | | | 3.6M | 5.0M | (02 12) |

MARCH 46001

D A T A S U M M A R Y

AVERAGE LATITUDE 56.0N AVERAGE LONGITUDE 147.8W

| MEANS AND EXTREMES | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | -00.1 | (05 06) | 02.2 | 04.8 | (25 00) | 247 | 31 |
| SEA TEMP (DEG C) | 03.0 | (04 21) | 03.2 | 03.8 | (18 00) | 247 | 31 |
| AIR-SEA TEMP (DEG C) | -03.4 | (05 08) | -01.0 | 01.3 | (25 00) | 247 | 31 |
| PRESSURE (MBAR) | 0982.8 | (07 06) | 1003.4 | 1016.4 | (22 06) | 247 | 31 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| DIR | SPEED (KNOTS) <4 | 4-10 | 11-21 | 22-33 | 34-47 | >47 | TOTAL % | MEAN SPEED (KNOTS) | NO. OF OBS: 247 |
|---|---|---|---|---|---|---|---|---|---|
| N | 1.2 | 4.0 | 2.9 | 1.6 | | | 9.7 | 11.9 | MAX WIND |
| NE | 1.2 | 1.6 | 2.0 | | | | 4.9 | 8.0 | SPEED: 32 KNOTS |
| E | .4 | 1.6 | 7.3 | 2.0 | | | 11.3 | 16.9 | DIRECTION: 150 DEG |
| SE | .4 | 2.0 | 8.5 | 5.3 | | | 16.2 | 18.9 | DAY: 12 |
| S | | 3.2 | 10.9 | 5.2 | | | 19.3 | 19.0 | HOUR: 03 |
| SW | | 2.8 | 6.9 | 6.5 | | | 16.2 | 19.1 | |
| W | .8 | 4.9 | 8.7 | 4.5 | | | 18.8 | 15.2 | |
| NW | .8 | 2.0 | 1.6 | .8 | | | 5.3 | 11.0 | |
| CALM | 1.6 | | | | | | 1.6 | .0 | |
| TOTAL | 6.5 | 22.3 | 48.4 | 21.9 | | | 100.0 | 15.5 | |

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 248

| HEIGHT (M) | <1 | 1-1.5 | 2-2.5 | 3-3.5 | 4-5.5 | 6-7.5 | 8-9.5 | >9.5 | MEAN | MAX | (DA HR) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % FREQUENCY | | 25.2 | 31.7 | 29.7 | 11.8 | 2.4 | | | 2.7M | 8.6M | (20 18) |

MARCH 46002

D A T A S U M M A R Y

AVERAGE LATITUDE 49.9N AVERAGE LONGITUDE 130.0W

| MEANS AND EXTREMES | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | 07.8 | (01 06) | 10.2 | 12.2 | (24 21) | 248 | 31 |
| PRESSURE (MBAR) | 0980.0 | (04 12) | 1015.4 | 1030.8 | (14 08) | 248 | 31 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| DIR | SPEED (KNOTS) <4 | 4-10 | 11-21 | 22-33 | 34-47 | >47 | TOTAL % | MEAN SPEED (KNOTS) | NO. OF OBS: 248 |
|---|---|---|---|---|---|---|---|---|---|
| N | | 3.6 | 8.8 | 2.0 | | | 14.5 | 15.1 | MAX WIND |
| NE | 1.6 | 2.8 | 11.3 | 1.2 | | | 16.9 | 13.7 | SPEED: 31 KNOTS |
| E | .4 | 4.4 | 4.8 | .4 | | | 10.1 | 12.1 | DIRECTION: 180 DEG |
| SE | .4 | 3.2 | 3.2 | | | | 6.9 | 10.3 | DAY: 07 |
| S | | 9.1 | 11.7 | 9.4 | | | 29.3 | 14.9 | HOUR: 03 |
| SW | .4 | 4.4 | 9.1 | 1.2 | | | 14.1 | 14.0 | |
| W | .4 | 3.6 | 1.2 | | | | 5.3 | 9.6 | |
| NW | .4 | 3.8 | 6.5 | .4 | | | 10.1 | 12.4 | |
| CALM | .4 | | | | | | .4 | 0.0 | |
| TOTAL | 4.0 | 33.9 | 52.4 | 8.7 | | | 100.0 | 13.4 | |

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 247

| HEIGHT (M) | <1 | 1-1.5 | 2-2.5 | 3-3.5 | 4-5.5 | 6-7.5 | 8-9.5 | >9.5 | MEAN | MAX | (DA HR) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % FREQUENCY | | 17.4 | 52.2 | 28.7 | 5.7 | | | | 2.4M | 5.5M | (07 15) |

MARCH 46003

D A T A S U M M A R Y

AVERAGE LATITUDE 52.0N AVERAGE LONGITUDE 168.0W

| MEANS AND EXTREMES | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | -01.1 | (07 21) | 03.1 | 06.3 | (11 18) | 247 | 31 |
| SEA TEMP (DEG C) | 02.8 | (29 20) | 02.8 | 03.1 | (11 18) | 247 | 31 |
| AIR-SEA TEMP (DEG C) | -04.0 | (07 21) | -00.8 | 02.2 | (11 18) | 247 | 31 |
| PRESSURE (MBAR) | 0978.3 | (27 00) | 1000.7 | 1022.1 | (21 21) | 248 | 31 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| DIR | SPEED (KNOTS) <4 | 4-10 | 11-21 | 22-33 | 34-47 | >47 | TOTAL % | MEAN SPEED (KNOTS) | NO. OF OBS: 248 |
|---|---|---|---|---|---|---|---|---|---|
| N | .4 | | 8.9 | | | | 9.3 | 13.4 | MAX WIND |
| NE | | .8 | 2.2 | | | | 3.0 | 14.2 | SPEED: 42 KNOTS |
| E | | .8 | 14.5 | 4.8 | .4 | | 20.6 | 18.8 | DIRECTION: 280 DEG |
| SE | | .8 | 6.5 | 2.4 | .8 | | 10.5 | 21.3 | DAY: 09 |
| S | | 2.4 | 7.7 | 1.6 | .8 | | 12.5 | 16.8 | HOUR: 03 |
| SW | .8 | 1.2 | 4.8 | 9.5 | 2.4 | | 17.7 | 23.1 | |
| W | | 1.6 | 10.5 | 4.4 | .8 | | 17.7 | 18.8 | |
| NW | | .8 | 8.9 | 4.4 | | | 14.1 | 18.3 | |
| CALM | | | | | | | | | |
| TOTAL | 1.2 | 8.1 | 59.5 | 28.2 | 5.2 | | 100.0 | 19.9 | |

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 248

| HEIGHT (M) | <1 | 1-1.5 | 2-2.5 | 3-3.5 | 4-5.5 | 6-7.5 | 8-9.5 | >9.5 | MEAN | MAX | (DA HR) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % FREQUENCY | | 10.9 | 39.1 | 27.4 | 20.2 | 6.0 | .4 | | 3.2M | 8.5M | (12 06) |

MARCH 46006

D A T A S U M M A R Y

AVERAGE LATITUDE 48.8N AVERAGE LONGITUDE 131.0W

| MEANS AND EXTREMES | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | 08.4 | (13 21) | 09.8 | 11.0 | (05 18) | 242 | 31 |
| SEA TEMP (DEG C) | 08.7 | (14 15) | 09.0 | 09.3 | (31 00) | 242 | 31 |
| AIR-SEA TEMP (DEG C) | -03.3 | (13 21) | -00.4 | 02.0 | (06 18) | 242 | 31 |
| PRESSURE (MBAR) | 0995.2 | (07 09) | 1014.9 | 1029.5 | (14 18) | 242 | 31 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| DIR | SPEED (KNOTS) <4 | 4-10 | 11-21 | 22-33 | 34-47 | >47 | TOTAL % | MEAN SPEED (KNOTS) | NO. OF OBS: 242 |
|---|---|---|---|---|---|---|---|---|---|
| N | .8 | 4.1 | 7.4 | | | | 12.4 | 13.1 | MAX WIND |
| NE | .8 | 5.4 | 6.2 | 5.8 | | | 18.2 | 15.2 | SPEED: 34 KNOTS |
| E | 1.2 | 2.9 | 3.3 | | | | 7.4 | 9.2 | DIRECTION: 170 DEG |
| SE | | 2.1 | 2.1 | .4 | | | 4.5 | 12.4 | DAY: 08 |
| S | | 3.7 | 13.6 | 9.6 | .4 | | 27.3 | 16.9 | HOUR: 12 |
| SW | | 5.0 | 8.7 | 1.2 | | | 14.9 | 14.1 | |
| W | .4 | 1.7 | 3.3 | .4 | | | 5.8 | 11.7 | |
| NW | 1.2 | 2.9 | 3.3 | 1.7 | | | 9.1 | 12.8 | |
| CALM | 1.2 | | | | | | 1.2 | .0 | |
| TOTAL | 5.8 | 27.3 | 47.9 | 19.0 | .4 | | 100.0 | 14.6 | |

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 242

| HEIGHT (M) | <1 | 1-1.5 | 2-2.5 | 3-3.5 | 4-5.5 | 6-7.5 | 8-9.5 | >9.5 | MEAN | MAX | (DA HR) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % FREQUENCY | | 13.2 | 48.8 | 31.4 | 6.6 | | | | 2.6M | 5.5M | (07 15) |

MARCH 46008

D A T A S U M M A R Y

AVERAGE LATITUDE 41.1N AVERAGE LONGITUDE 137.8W

| MEANS AND EXTREMES | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | 08.0 | (08 03) | 10.4 | 12.8 | (26 09) | 247 | 31 |
| PRESSURE (MBAR) | 0983.4 | (08 21) | 1015.1 | 1031.8 | (11 09) | 247 | 31 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| DIR | SPEED (KNOTS) <4 | 4-10 | 11-21 | 22-33 | 34-47 | >47 | TOTAL % | MEAN SPEED (KNOTS) | NO. OF OBS: 248 |
|---|---|---|---|---|---|---|---|---|---|
| N | | 1.2 | 9.3 | 3.2 | | | 13.7 | 16.0 | MAX WIND |
| NE | | 2.0 | 9.3 | | | | 11.3 | 14.4 | SPEED: 38 KNOTS |
| E | .4 | 1.2 | 5.6 | 3.6 | | | 10.9 | 18.4 | DIRECTION: 180 DEG |
| SE | | | 3.0 | 2.4 | | | 5.6 | 19.3 | DAY: 08 |
| S | | | 2.8 | 7.3 | .4 | | 10.5 | 18.9 | HOUR: 03 |
| SW | | 3.8 | 11.7 | 5.6 | | | 21.0 | 17.4 | |
| W | .4 | 1.6 | 7.3 | 4.4 | | | 13.8 | 18.2 | |
| NW | .4 | 1.2 | 6.4 | 2.4 | | | 9.5 | 16.7 | |
| CALM | | | | | | | | | |
| TOTAL | 1.2 | 14.1 | 56.9 | 27.8 | .4 | | 100.0 | 17.4 | |

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 241

| HEIGHT (M) | <1 | 1-1.5 | 2-2.5 | 3-3.5 | 4-5.5 | 6-7.5 | 8-9.5 | >9.5 | MEAN | MAX | (DA HR) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % FREQUENCY | | 7.9 | 38.2 | 37.3 | 15.8 | | | | 2.9M | 5.9M | (07 00) |

MARCH 46087

D A T A S U M M A R Y

AVERAGE LATITUDE 59.2N AVERAGE LONGITUDE 152.7W

| MEANS AND EXTREMES | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | -04.0 | (18 18) | 00.9 | 04.0 | (12 21) | 199 | 26 |
| SEA TEMP (DEG C) | 03.2 | (24 06) | 04.3 | 05.0 | (25 09) | 197 | 25 |
| AIR-SEA TEMP (DEG C) | -09.5 | (18 21) | -03.3 | 00.4 | (25 09) | 197 | 25 |
| PRESSURE (MBAR) | 0983.8 | (07 18) | 1002.1 | 1022.5 | (22 09) | 198 | 25 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| DIR | SPEED (KNOTS) <4 | 4-10 | 11-21 | 22-33 | 34-47 | >47 | TOTAL % | MEAN SPEED (KNOTS) | NO. OF OBS: 198 |
|---|---|---|---|---|---|---|---|---|---|
| N | .5 | 3.1 | 15.3 | | | | 18.8 | 12.7 | MAX WIND |
| NE | | 1.5 | 25.0 | | | | 26.5 | 14.8 | SPEED: 31 KNOTS |
| E | .5 | 4.1 | 10.7 | 4.1 | | | 19.4 | 19.2 | DIRECTION: 100 DEG |
| SE | | 1.0 | 5.6 | | | | 6.6 | 13.8 | DAY: 12 |
| S | | .5 | 1.5 | | | | 2.0 | 11.0 | HOUR: 08 |
| SW | | | 2.0 | 1.0 | | | 3.0 | 18.0 | |
| W | .5 | 2.0 | 12.2 | 5.6 | | | 20.4 | 18.9 | |
| NW | .5 | 2.0 | 5.1 | | | | 7.7 | 12.6 | |
| CALM | | | | | | | | | |
| TOTAL | 2.0 | 14.3 | 74.0 | 9.7 | | | 100.0 | 14.8 | |

% OF OBS WITH POTENTIAL SUPERSTRUCTURE ICING - MODERATE: 6.7% SEVERE: NONE OBS: 195

APRIL 46001

D A T A S U M M A R Y

AVERAGE LATITUDE 56.0N AVERAGE LONGITUDE 147.8W

| MEANS AND EXTREMES | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | 01.9 | (08 18) | 03.8 | 05.5 | (20 09) | 240 | 30 |
| SEA TEMP (DEG C) | 03.4 | (07 00) | 03.8 | 04.2 | (22 00) | 240 | 30 |
| AIR-SEA TEMP (DEG C) | -02.9 | (22 00) | -00.3 | 00.8 | (20 21) | 240 | 30 |
| PRESSURE (MBAR) | 0981.3 | (07 08) | 1010.8 | 1033.5 | (15 21) | 240 | 30 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| DIR | SPEED (KNOTS) <4 | 4-10 | 11-21 | 22-33 | 34-47 | >47 | TOTAL % | MEAN SPEED (KNOTS) | NO. OF OBS: 240 |
|---|---|---|---|---|---|---|---|---|---|
| N | .4 | 2.5 | 2.9 | | | | 5.8 | 10.0 | MAX WIND |
| NE | .4 | 4.6 | 1.3 | | | | 6.3 | 8.3 | SPEED: 35 KNOTS |
| E | 2.1 | 2.5 | 1.7 | 2.1 | | | 8.3 | 12.8 | DIRECTION: 140 DEG |
| SE | | 3.8 | 11.3 | 3.8 | .4 | | 19.2 | 15.8 | DAY: 06 |
| S | .8 | 2.9 | 6.3 | 5.0 | | | 15.0 | 16.2 | HOUR: 18 |
| SW | .4 | 2.5 | 7.1 | 4.2 | | | 14.2 | 17.1 | |
| W | | 5.4 | 10.4 | 4.2 | | | 20.0 | 14.8 | |
| NW | .4 | 4.6 | 5.0 | 1.7 | | | 11.7 | 13.5 | |
| CALM | .8 | | | | | | .8 | .0 | |
| TOTAL | 5.4 | 28.8 | 48.3 | 18.8 | .4 | | 100.0 | 14.1 | |

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 240

| HEIGHT (M) | <1 | 1-1.5 | 2-2.5 | 3-3.5 | 4-5.5 | 6-7.5 | 8-9.5 | >9.5 | MEAN | MAX | (DA HR) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % FREQUENCY | | 2.9 | 29.2 | 41.3 | 17.1 | 9.6 | | | 2.9M | 5.8M | (30 06) |

APRIL 46002

D A T A S U M M A R Y

AVERAGE LATITUDE 49.9N AVERAGE LONGITUDE 130.0W

| MEANS AND EXTREMES | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | 08.0 | (08 18) | 08.8 | 10.1 | (28 00) | 240 | 30 |
| PRESSURE (MBAR) | 0988.0 | (05 00) | 1018.7 | 1033.5 | (11 18) | 240 | 30 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| DIR | SPEED (KNOTS) <4 | 4-10 | 11-21 | 22-33 | 34-47 | >47 | TOTAL % | MEAN SPEED (KNOTS) | NO. OF OBS: 240 |
|---|---|---|---|---|---|---|---|---|---|
| N | | 5.4 | 8.3 | 3.3 | | | 17.1 | 15.1 | MAX WIND |
| NE | | 3.8 | | | | | 3.8 | 6.8 | SPEED: 36 KNOTS |
| E | | 1.3 | .4 | | | | 1.7 | 8.8 | DIRECTION: 140 DEG |
| SE | | | 2.9 | 2.9 | | | 5.8 | 20.9 | DAY: 24 |
| S | .4 | 1.7 | 2.9 | | | | 5.0 | 11.5 | HOUR: 02 |
| SW | .4 | 2.5 | 6.7 | .8 | | | 10.4 | 15.8 | |
| W | 1.3 | 5.4 | 22.5 | 2.1 | | | 31.3 | 14.4 | |
| NW | | 8.3 | 14.2 | 2.5 | | | 25.0 | 14.3 | |
| CALM | .4 | | | | | | .4 | .0 | |
| TOTAL | 2.1 | 28.3 | 59.3 | 11.5 | | | 100.0 | 14.4 | |

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 240

| HEIGHT (M) | <1 | 1-1.5 | 2-2.5 | 3-3.5 | 4-5.5 | 6-7.5 | 8-9.5 | >9.5 | MEAN | MAX | (DA HR) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % FREQUENCY | | 38.3 | 52.1 | 13.8 | 5.8 | | | | 2.2M | 5.5M | (08 00) |

APRIL 46003

D A T A S U M M A R Y

AVERAGE LATITUDE 52.0N AVERAGE LONGITUDE 168.0W

| MEANS AND EXTREMES | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | 01.7 | (08 00) | 03.0 | 04.6 | (14 03) | 240 | 30 |
| SEA TEMP (DEG C) | 02.8 | (29 03) | 02.9 | 03.0 | (29 03) | 240 | 30 |
| AIR-SEA TEMP (DEG C) | -03.0 | (23 09) | -00.3 | 01.5 | (13 21) | 238 | 30 |
| PRESSURE (MBAR) | 0982.3 | (28 21) | 1009.7 | 1034.4 | (13 09) | 240 | 30 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| DIR | SPEED (KNOTS) <4 | 4-10 | 11-21 | 22-33 | 34-47 | >47 | TOTAL % | MEAN SPEED (KNOTS) | NO. OF OBS: 240 |
|---|---|---|---|---|---|---|---|---|---|
| N | | 1.7 | .4 | | | | 2.1 | 8.0 | MAX WIND |
| NE | .4 | 2.1 | .8 | | | | 3.3 | 8.1 | SPEED: 34 KNOTS |
| E | .4 | .8 | | 1.3 | | | 2.5 | 14.5 | DIRECTION: 180 DEG |
| SE | | 1.3 | 2.5 | 2.5 | | | 6.3 | 18.0 | DAY: 06 |
| S | .4 | 4.2 | 12.5 | 3.8 | .4 | | 20.0 | 15.8 | HOUR: 06 |
| SW | .4 | 4.2 | 19.0 | 10.4 | | | 30.0 | 19.3 | |
| W | .8 | 2.5 | 15.0 | 5.8 | | | 24.2 | 17.1 | |
| NW | | 1.7 | 9.0 | 2.1 | | | 12.8 | 16.0 | |
| CALM | 2.1 | | | | | | 2.1 | .0 | |
| TOTAL | 4.0 | 18.3 | 63.6 | 24.2 | .4 | | 100.0 | 18.3 | |

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 240

| HEIGHT (M) | <1 | 1-1.5 | 2-2.5 | 3-3.5 | 4-5.5 | 6-7.5 | 8-9.5 | >9.5 | MEAN | MAX | (DA HR) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % FREQUENCY | .4 | 10.8 | 44.8 | 24.6 | 9.6 | 1.3 | | | 2.8M | 8.0M | (08 00) |

APRIL 46006

D A T A S U M M A R Y

AVERAGE LATITUDE 48.8N AVERAGE LONGITUDE 131.0W

| MEANS AND EXTREMES | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | 09.0 | (14 09) | 09.5 | 10.0 | (28 00) | 233 | 30 |
| SEA TEMP (DEG C) | 08.9 | (06 15) | 09.4 | 10.7 | (28 21) | 235 | 30 |
| AIR-SEA TEMP (DEG C) | -03.0 | (14 09) | -01.1 | 01.2 | (28 18) | 233 | 30 |
| PRESSURE (MBAR) | 1000.1 | (25 00) | 1014.9 | 1034.3 | (11 18) | 234 | 30 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| DIR | SPEED (KNOTS) <4 | 4-10 | 11-21 | 22-33 | 34-47 | >47 | TOTAL % | MEAN SPEED (KNOTS) | NO. OF OBS: 234 |
|---|---|---|---|---|---|---|---|---|---|
| N | .8 | 4.3 | 7.3 | | | | 12.4 | 11.0 | MAX WIND |
| NE | | 3.0 | | | | | 3.0 | 9.1 | SPEED: 43 KNOTS |
| E | .4 | 2.6 | .8 | 3.8 | | | 7.7 | 17.0 | DIRECTION: 250 DEG |
| SE | | 3.4 | 1.3 | | | | 4.7 | 9.5 | DAY: 05 |
| S | | 3.8 | 6.8 | 1.7 | | | 12.4 | 14.6 | HOUR: 12 |
| SW | .9 | 1.7 | 7.3 | | | | 9.8 | 11.9 | |
| W | .4 | 5.6 | 15.2 | 3.8 | .4 | | 25.5 | 16.4 | |
| NW | | 3.8 | 14.5 | 4.7 | | | 23.1 | 16.5 | |
| CALM | .4 | | | | | | .4 | .0 | |
| TOTAL | 3.0 | 28.2 | 54.9 | 14.1 | .4 | | 100.0 | 14.4 | |

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 234

| HEIGHT (M) | <1 | 1-1.5 | 2-2.5 | 3-3.5 | 4-5.5 | 6-7.5 | 8-9.5 | >9.5 | MEAN | MAX | (DA HR) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % FREQUENCY | | 22.2 | 58.0 | 17.1 | 3.4 | 1.3 | | | 2.3M | 7.9M | (05 15) |

APRIL 46008

D A T A S U M M A R Y

AVERAGE LATITUDE 41.1N AVERAGE LONGITUDE 137.8W

| MEANS AND EXTREMES | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | 05.7 | (18 18) | 09.4 | 12.2 | (29 06) | 239 | 30 |
| PRESSURE (MBAR) | 0987.2 | (24 06) | 1020.8 | 1038.0 | (11 18) | 238 | 30 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| DIR | SPEED (KNOTS) <4 | 4-10 | 11-21 | 22-33 | 34-47 | >47 | TOTAL % | MEAN SPEED (KNOTS) | NO. OF OBS: 239 |
|---|---|---|---|---|---|---|---|---|---|
| N | | | 5.9 | 3.3 | | | 9.2 | 15.0 | MAX WIND |
| NE | | .4 | 10.5 | | | | 10.9 | 15.7 | SPEED: 32 KNOTS |
| E | .8 | .4 | 1.3 | .8 | | | 3.3 | 13.8 | DIRECTION: 310 DEG |
| SE | | 1.3 | 2.1 | .4 | | | 3.8 | 12.2 | DAY: 24 |
| S | .8 | | 4.6 | | | | 5.8 | 12.4 | HOUR: 21 |
| SW | | .8 | 3.3 | 1.7 | | | 5.8 | 16.8 | |
| W | .4 | 4.6 | 21.8 | 1.3 | | | 28.0 | 16.4 | |
| NW | 1.3 | 2.1 | 15.1 | 14.8 | | | 33.1 | 20.0 | |
| CALM | .4 | | | | | | .4 | .0 | |
| TOTAL | 3.3 | 10.5 | 80.3 | 26.0 | | | 100.0 | 17.4 | |

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 237

| HEIGHT (M) | <1 | 1-1.5 | 2-2.5 | 3-3.5 | 4-5.5 | 6-7.5 | 8-9.5 | >9.5 | MEAN | MAX | (DA HR) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % FREQUENCY | | 10.0 | 55.3 | 24.5 | 8.9 | | | | 2.4M | 6.0M | (09 21) |

APRIL 46087

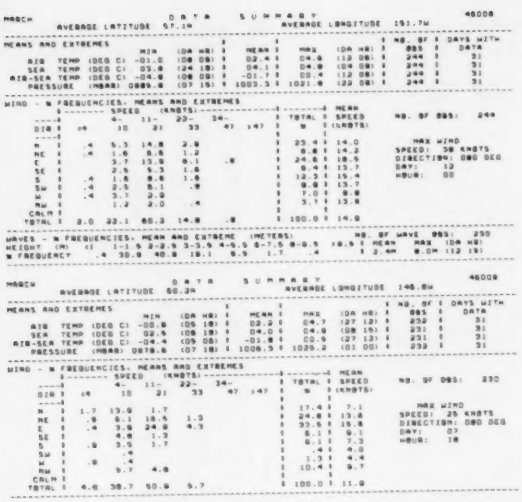
D A T A S U M M A R Y

AVERAGE LATITUDE 59.2N AVERAGE LONGITUDE 152.7W

| MEANS AND EXTREMES | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | -01.2 | (10 18) | 03.4 | 06.8 | (30 03) | 197 | 30 |
| SEA TEMP (DEG C) | 03.4 | (05 03) | 04.6 | 05.8 | (29 03) | 193 | 30 |
| AIR-SEA TEMP (DEG C) | -06.1 | (10 18) | -01.1 | 01.8 | (30 09) | 193 | 30 |
| PRESSURE (MBAR) | 0988.1 | (07 15) | 1009.5 | 1032.1 | (13 21) | 198 | 30 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| DIR | SPEED (KNOTS) <4 | 4-10 | 11-21 | 22-33 | 34-47 | >47 | TOTAL % | MEAN SPEED (KNOTS) | NO. OF OBS: 198 |
|---|---|---|---|---|---|---|---|---|---|
| N | | 2.5 | 2.5 | | | | 5.1 | 8.6 | MAX WIND |
| NE | | 5.8 | 7.9 | | | | 13.1 | 11.5 | SPEED: 35 KNOTS |
| E | .5 | 5.8 | 20.7 | .5 | | | 27.3 | 13.9 | DIRECTION: 100 DEG |
| SE | | 6.1 | 8.1 | | | | 14.1 | 11.0 | DAY: 28 |
| S | | 2.0 | 1.0 | | | | 3.0 | 9.7 | HOUR: 06 |
| SW | | 2.5 | | | | | 2.5 | 8.6 | |
| W | 1.9 | 9.1 | 12.6 | 3.0 | | | 26.3 | 13.0 | |
| NW | | 3.5 | 5.1 | | | | 8.6 | 12.6 | |
| CALM | | | | | | | | | |
| TOTAL | 2.0 | 35.9 | 58.6 | 3.5 | | | 100.0 | 12.9 | |



MARCH D A T A S U M M A R Y 46006

AVERAGE LATITUDE 57.1N AVERAGE LONGITUDE 151.7W

MEANS AND EXTREMES

| | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | -01.0 | (08 09) | 02.4 | 04.8 | (12 08) | 244 | 31 |
| SEA TEMP (DEG C) | 03.8 | (24 18) | 04.1 | 04.9 | (04 08) | 244 | 31 |
| AIR-SEA TEMP (DEG C) | -04.6 | (08 09) | -01.7 | 00.4 | (12 08) | 244 | 31 |
| PRESSURE (MBAR) | 0985.6 | (07 15) | 1003.5 | 1031.6 | (22 00) | 244 | 31 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| DIR | SPEED (KNOTS) <4 | 4-10 | 11-21 | 22-33 | 34-47 | >47 | TOTAL % | MEAN SPEED (KNOTS) |
|---|---|---|---|---|---|---|---|---|
| N | | | | | | | 23.4 | 14.0 |
| NE | .4 | 5.3 | 14.8 | 2.9 | | | 9.8 | 14.2 |
| E | .4 | 1.6 | 8.6 | 1.2 | | | 24.6 | 18.5 |
| SE | | 3.7 | 13.9 | 8.1 | .8 | | 6.4 | 13.7 |
| S | | 2.5 | 5.3 | 1.6 | | | 12.3 | 15.4 |
| SW | .4 | 1.6 | 8.6 | 1.6 | | | 9.8 | 13.7 |
| W | .4 | 2.5 | 5.1 | .8 | | | 7.0 | 9.8 |
| NW | .4 | 3.7 | 2.8 | | | | 3.1 | 13.8 |
| CALM | | 1.2 | 2.0 | .4 | | | | |
| TOTAL | 2.0 | 22.1 | 68.3 | 14.8 | .8 | | 100.0 | 14.0 |

MAX WIND
SPEED: 58 KNOTS
DIRECTION: 080 DEG
DAY: 12
HOUR: 00

NO. OF OBS: 244

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 250

| HEIGHT (M) | <1 | 1-1.5 | 2-2.5 | 3-3.5 | 4-5.5 | 6-7.5 | 8-9.5 | >9.5 | MEAN | MAX | (DA HR) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % FREQUENCY | .4 | 30.8 | 40.8 | 18.1 | 9.5 | 1.7 | .4 | | 2.0M | 8.0M | (12 19) |

MARCH D A T A S U M M A R Y 46009

AVERAGE LATITUDE 50.2N AVERAGE LONGITUDE 146.8W

MEANS AND EXTREMES

| | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | -00.8 | (05 18) | 02.2 | 04.7 | (27 12) | 252 | 31 |
| SEA TEMP (DEG C) | 02.5 | (06 18) | 04.0 | 04.8 | (08 15) | 231 | 31 |
| AIR-SEA TEMP (DEG C) | -02.4 | (05 08) | -01.8 | 02.5 | (27 12) | 231 | 31 |
| PRESSURE (MBAR) | 0978.6 | (07 18) | 1006.5 | 1035.2 | (01 00) | 233 | 31 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| DIR | SPEED (KNOTS) <4 | 4-10 | 11-21 | 22-33 | 34-47 | >47 | TOTAL % | MEAN SPEED (KNOTS) |
|---|---|---|---|---|---|---|---|---|
| N | | | | | | | 17.4 | 7.1 |
| NE | 1.7 | 13.9 | 1.7 | | | | 24.8 | 13.8 |
| E | .8 | 5.1 | 18.5 | 1.3 | | | 33.5 | 15.8 |
| SE | .4 | 3.9 | 24.9 | 4.3 | | | 8.1 | 9.1 |
| S | | 4.8 | 1.3 | | | | 6.1 | 7.3 |
| SW | .8 | 3.5 | 1.7 | | | | 4.4 | 4.0 |
| W | | .4 | | | | | 1.3 | 4.4 |
| NW | .8 | | | | | | 10.4 | 9.7 |
| CALM | | | | | | | | |
| TOTAL | 4.6 | 32.7 | 50.8 | 5.7 | | | 100.0 | 11.9 |

MAX WIND
SPEED: 25 KNOTS
DIRECTION: 080 DEG
DAY: 07
HOUR: 18

NO. OF OBS: 230

APRIL D A T A S U M M A R Y 46008

AVERAGE LATITUDE 57.1N AVERAGE LONGITUDE 151.7W

MEANS AND EXTREMES

| | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | 01.1 | (06 12) | 03.8 | 06.3 | (13 03) | 219 | 30 |
| SEA TEMP (DEG C) | 03.9 | (02 18) | 04.4 | 05.3 | (30 08) | 217 | 30 |
| AIR-SEA TEMP (DEG C) | -03.0 | (06 12) | -00.5 | 02.1 | (12 03) | 217 | 30 |
| PRESSURE (MBAR) | 0987.4 | (26 15) | 1010.0 | 1032.8 | (13 21) | 218 | 30 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| DIR | SPEED (KNOTS) <4 | 4-10 | 11-21 | 22-33 | 34-47 | >47 | TOTAL % | MEAN SPEED (KNOTS) |
|---|---|---|---|---|---|---|---|---|
| N | | | | | | | 8.7 | 12.5 |
| NE | .9 | 2.3 | 6.5 | | | | 5.1 | 8.3 |
| E | .5 | 3.7 | 6.9 | 7.4 | | | 18.4 | 17.5 |
| SE | | 5.1 | 6.9 | 4.6 | | | 16.1 | 17.0 |
| S | .9 | 1.8 | 8.8 | 4.6 | | | 20.7 | 18.9 |
| SW | .5 | 4.6 | 14.5 | .9 | | | 15.2 | 13.5 |
| W | .5 | 4.1 | 7.8 | 2.8 | | | 9.3 | 9.7 |
| NW | .9 | 3.2 | 4.1 | | | | 5.1 | 9.8 |
| CALM | .5 | | | | | | .5 | .0 |
| TOTAL | 5.1 | 28.1 | 51.2 | 19.7 | | | 100.0 | 13.8 |

MAX WIND
SPEED: 33 KNOTS
DIRECTION: 070 DEG
DAY: 29
HOUR: 06

NO. OF OBS: 217

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 187

| HEIGHT (M) | <1 | 1-1.5 | 2-2.5 | 3-3.5 | 4-5.5 | 6-7.5 | 8-9.5 | >9.5 | MEAN | MAX | (DA HR) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % FREQUENCY | 5.9 | 41.2 | 32.1 | 11.8 | 9.1 | | | | 2.0M | 6.0M | (30 12) |

APRIL D A T A S U M M A R Y 46009

AVERAGE LATITUDE 50.2N AVERAGE LONGITUDE 146.8W

MEANS AND EXTREMES

| | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | 01.0 | (05 18) | 04.3 | 07.0 | (22 03) | 195 | 30 |
| SEA TEMP (DEG C) | 03.9 | (03 03) | 04.9 | 06.3 | (25 00) | 193 | 30 |
| AIR-SEA TEMP (DEG C) | -03.4 | (08 18) | -00.6 | 02.0 | (22 03) | 191 | 30 |
| PRESSURE (MBAR) | 0980.6 | (07 19) | 1011.9 | 1032.7 | (13 21) | 190 | 30 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| DIR | SPEED (KNOTS) <4 | 4-10 | 11-21 | 22-33 | 34-47 | >47 | TOTAL % | MEAN SPEED (KNOTS) |
|---|---|---|---|---|---|---|---|---|
| N | 9.7 | 10.5 | 2.1 | | | | 22.5 | 8.2 |
| NE | .5 | 2.1 | 11.2 | | | | 13.9 | 13.7 |
| E | .5 | 8.5 | 15.4 | | | | 24.5 | 11.1 |
| SE | | 3.2 | 2.7 | | | | 5.9 | 8.8 |
| S | 1.1 | 4.8 | 1.6 | | | | 7.4 | 7.2 |
| SW | 2.7 | 1.6 | | | | | 4.3 | 4.5 |
| W | 3.7 | | | | | | 3.7 | 2.3 |
| NW | 2.1 | 8.5 | 6.8 | | | | 17.6 | 8.9 |
| CALM | .5 | | | | | | .5 | .0 |
| TOTAL | 14.9 | 46.2 | 39.8 | | | | 100.0 | 8.0 |

MAX WIND
SPEED: 21 KNOTS
DIRECTION: 070 DEG
DAY: 26
HOUR: 12

NO. OF OBS: 188

APRIL D A T A S U M M A R Y 41001

AVERAGE LATITUDE 39.0N AVERAGE LONGITUDE 072.0W

MEANS AND EXTREMES

| | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | 12.4 | (16 18) | 17.1 | 20.5 | (30 21) | 123 | 16 |
| SEA TEMP (DEG C) | 18.4 | (28 15) | 20.2 | 21.1 | (25 21) | 123 | 16 |
| AIR-SEA TEMP (DEG C) | -08.0 | (16 18) | -03.1 | 00.5 | (30 21) | 123 | 16 |
| PRESSURE (MBAR) | 0995.2 | (27 21) | 1012.8 | 1023.2 | (17 15) | 123 | 16 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| DIR | SPEED (KNOTS) <4 | 4-10 | 11-21 | 22-33 | 34-47 | >47 | TOTAL % | MEAN SPEED (KNOTS) |
|---|---|---|---|---|---|---|---|---|
| N | | | | | | | 8.9 | 14.0 |
| NE | .8 | 1.6 | 6.5 | | | | 4.1 | 8.8 |
| E | | 3.3 | .8 | | | | 8.9 | 10.9 |
| SE | | 3.3 | 1.6 | 9.1 | | | 14.6 | 16.0 |
| S | .8 | .8 | 11.0 | 1.6 | | | 13.8 | 16.0 |
| SW | .8 | 1.6 | 7.3 | 8.1 | | | 17.1 | 18.5 |
| W | | 2.4 | 13.8 | 1.6 | | | 17.1 | 17.4 |
| NW | | 3.3 | 8.1 | 5.7 | | | 20.3 | 20.6 |
| CALM | | 2.4 | 8.9 | 8.5 | 2.4 | | | |
| TOTAL | 2.4 | 18.7 | 48.8 | 27.6 | 2.4 | | 100.0 | 17.4 |

MAX WIND
SPEED: 37 KNOTS
DIRECTION: 320 DEG
DAY: 26
HOUR: 12

NO. OF OBS: 123

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 123

| HEIGHT (M) | <1 | 1-1.5 | 2-2.5 | 3-3.5 | 4-5.5 | 6-7.5 | 8-9.5 | >9.5 | MEAN | MAX | (DA HR) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % FREQUENCY | 2.4 | 40.7 | 30.9 | 18.5 | 8.9 | | | | 2.1M | 5.0M | (28 15) |

APRIL D A T A S U M M A R Y 43001

AVERAGE LATITUDE 28.0N AVERAGE LONGITUDE 080.0W

MEANS AND EXTREMES

| | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | 19.4 | (26 18) | 23.2 | 25.2 | (22 21) | 228 | 30 |
| SEA TEMP (DEG C) | 18.4 | (28 06) | 23.2 | 26.0 | (17 00) | 221 | 30 |
| AIR-SEA TEMP (DEG C) | -04.5 | (27 03) | 00.0 | 03.4 | (22 21) | 221 | 30 |
| PRESSURE (MBAR) | 1007.9 | (30 21) | 1019.5 | 1024.6 | (04 15) | 228 | 30 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| DIR | SPEED (KNOTS) <4 | 4-10 | 11-21 | 22-33 | 34-47 | >47 | TOTAL % | MEAN SPEED (KNOTS) |
|---|---|---|---|---|---|---|---|---|
| N | | 4.4 | 8.0 | | | | 12.4 | 11.7 |
| NE | | 6.2 | 7.1 | | | | 13.8 | 10.3 |
| E | .4 | 7.5 | 5.8 | | | | 13.8 | 9.5 |
| SE | | 21.3 | 17.8 | | | | 39.1 | 10.5 |
| S | .9 | 4.4 | 10.2 | | | | 15.8 | 12.3 |
| SW | | .4 | 1.8 | | | | 2.2 | 12.8 |
| W | | | 1.3 | | | | 1.3 | 14.0 |
| NW | .4 | | 1.3 | | | | 1.8 | 11.0 |
| CALM | | | | | | | | |
| TOTAL | 1.8 | 44.9 | 53.3 | | | | 100.0 | 10.9 |

MAX WIND
SPEED: 21 KNOTS
DIRECTION: 120 DEG
DAY: 29
HOUR: 06

NO. OF OBS: 228

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 209

| HEIGHT (M) | <1 | 1-1.5 | 2-2.5 | 3-3.5 | 4-5.5 | 6-7.5 | 8-9.5 | >9.5 | MEAN | MAX | (DA HR) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % FREQUENCY | 18.0 | 77.2 | 4.8 | | | | | | 1.1M | 2.5M | (28 15) |

APRIL D A T A S U M M A R Y 44003

AVERAGE LATITUDE 40.0N AVERAGE LONGITUDE 068.5W

MEANS AND EXTREMES

| | MIN | (DA HR) | MEAN | MAX | (DA HR) | NO. OF OBS | DAYS WITH DATA |
|---|---|---|---|---|---|---|---|
| AIR TEMP (DEG C) | 02.7 | (10 18) | 09.5 | 09.8 | (20 21) | 177 | 24 |
| SEA TEMP (DEG C) | 04.3 | (09 12) | 09.3 | 09.7 | (19 18) | 178 | 24 |
| AIR-SEA TEMP (DEG C) | -01.8 | (10 18) | 00.5 | 04.8 | (20 12) | 178 | 24 |
| PRESSURE (MBAR) | 0995.1 | (28 18) | 1010.8 | 1025.1 | (17 15) | 177 | 24 |

WIND - % FREQUENCIES, MEANS AND EXTREMES

| DIR | SPEED (KNOTS) <4 | 4-10 | 11-21 | 22-33 | 34-47 | >47 | TOTAL % | MEAN SPEED (KNOTS) |
|---|---|---|---|---|---|---|---|---|
| N | 1.1 | 5.3 | 4.6 | 2.3 | | | 14.1 | 11.9 |
| NE | .6 | 1.1 | | 3.4 | | | 5.1 | 18.0 |
| E | | 1.1 | 1.7 | 1.1 | | | 4.0 | 18.5 |
| SE | 1.7 | 2.3 | 4.0 | 1.1 | | | 9.0 | 12.2 |
| S | 2.3 | 1.1 | 3.4 | | | | 6.8 | 8.9 |
| SW | .6 | 4.5 | 8.5 | | | | 13.6 | 10.8 |
| W | 1.1 | 8.5 | 14.7 | | | | 24.3 | 11.3 |
| NW | 1.7 | 5.6 | 15.8 | | | | 23.2 | 11.5 |
| CALM | | | | | | | | |
| TOTAL | 9.0 | 30.9 | 52.6 | 7.9 | | | 100.0 | 11.9 |

MAX WIND
SPEED: 29 KNOTS
DIRECTION: 030 DEG
DAY: 28
HOUR: 06

NO. OF OBS: 177

(Continued from page 359.)

the 21st with resulting hold and engineroom flooding. Once out over the South China Sea Olive strengthened rapidly. She became the first typhoon of the year on the 22d. About this same time she began to recurve, northward then northeastward. Her maximum winds climbed to a peak of 85 kn on the 23d and 24th. On the 25th Olive passed through the Luzon Strait heading east-northeastward. The BRINTON LYKES (21°N, 121°E) and the PRESIDENT TAFT (20°N, 123°E) suffered 55- and 60-kn winds and 36- and 25-ft waves, respectively. She started weakening later that day, and the following day Olive was a tropical storm and becoming extratropical.

Casualties--The 4,938-ton British ALAUNIA sustained heavy weather damage on the 5th and 6th. Flooding caused damage to steering gear. South of the Equator, the 14,072-ton Australian ALLUNGA broke five aft mooring lines, pulled out one shore bollard, and fractured another during a severe squall at Suva, Fiji Islands on the 16th. The British-registered PORT VANCOUVER (35,716 tons) was at Kobe on the 25th with heavy weather damage, and weather damage to the bow of the American container barge ISLANDER was discovered while she was in drydock.

# Table 5
# Selected Gale and Wave Observations, North Atlantic
## March and April 1978

| Vessel | Nationality | Date | Position of Ship Lat. | Position of Ship Long. | Time GMT | Wind Dir. 10° | Wind Speed kt. | Visibility n. mi. | Present Weather code | Pressure mb | Temperature °C Air | Temperature °C Sea | Sea Waves* Period sec. | Sea Waves* Height ft | Swell Waves Dir. 10° | Swell Waves Period sec. | Swell Waves Height ft |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NORTH ATLANTIC OCEAN | | MAR. | deg. | deg. | | | | | | | | | | | | | |
| PAUL L FAHRNEY | LIBERIAN | 1 | 31.2 N | 71.1 W | 12 | 27 | M 45 | 5 NM | 02 | 998.0 | 21.1 | 20.0 | 10 | 19.5 | | | |
| METEOR(T-AKR9) | AMERICAN | 2 | 34.5 N | 50.5 W | 00 | 28 | M 07 | 3 NM | 02 | 995.5 | 12.4 | 20.0 | 5 | 6 | 27 | 9 | 26 |
| MONTICELLO VICTORY | AMERICAN | 2 | 38.4 N | 74.1 W | 18 | 31 | 45 | 10 NM | 02 | 1022.7 | 7.4 | 9.0 | 9 | 11.5 | | | |
| GREAT REPUBLIC | AMERICAN | 2 | 39.2 N | 45.8 W | 12 | 25 | 55 | 10 NM | 02 | 1002.5 | 17.1 | 19.5 | 12 | 19.5 | XX | | 19.5 |
| EXPORT LEADER | AMERICAN | 3 | 48.5 N | 35.0 W | 16 | 32 | 45 | 5 NM | 73 | 995.9 | 2.3 | 0.5 | 8 | 10 | | | |
| MONTICELLO VICTORY | AMERICAN | 3 | 33.1 N | 75.6 W | 18 | 17 | 00 | 10 NM | 02 | 1002.4 | 16.2 | 23.3 | 5 | 19.5 | | | |
| SEALAND PRODUCER | AMERICAN | 3 | 50.4 N | 41.9 W | 12 | 13 | 48 | 10 NM | 02 | 997.1 | 17.0 | 7.0 | 4 | 6.5 | 13 | 9 | 19.5 |
| EXPORT FREEDOM | AMERICAN | 3 | 39.1 N | 52.7 W | 12 | 30 | 48 | 5 NM | 91 | 997.7 | 5.0 | 15.0 | 6 | 10 | 90 | 9 | 19.5 |
| ALBANY | SWEDISH | 3 | 48.1 N | 41.6 W | 18 | 32 | 55 | 5 NM | 72 | 993.3 | 1.1 | 0.0 | | 13 | | | |
| GREAT REPUBLIC | AMERICAN | 4 | 35.2 N | 46.4 W | 00 | 27 | 50 | 10 NM | 02 | 1008.8 | 16.7 | 14.5 | 12 | 19.5 | | | |
| HOEGH ORRIS | NORWEGIAN | 4 | 38.5 N | 34.5 W | 12 | 25 | 49 | 5 NM | 03 | 1002.0 | 19.0 | 14.0 | XX | 29.5 | 25 | 12 | 49 |
| STAGHOUND | AMERICAN | 4 | 47.1 N | 24.7 W | 00 | 28 | 50 | 2 NM | 00 | 997.1 | 11.7 | 13.4 | 6 | 24.5 | | | |
| SEALAND PRODUCER | AMERICAN | 4 | 50.8 N | 25.1 W | 00 | 13 | 48 | 10 NM | 02 | 997.9 | 10.6 | 8.3 | 4 | 6.5 | 13 | 9 | 21 |
| TRINITY | AMERICAN | 4 | 39.7 N | 72.5 W | 06 | 35 | 41 | 5 NM | 26 | 999.4 | 6.0 | 6.7 | 4 | 14.5 | 33 | 7 | 18.5 |
| MONTICELLO VICTORY | AMERICAN | 4 | 32.4 N | 76.1 W | 00 | 30 | 45 | 10 NM | 02 | 997.6 | 17.2 | 22.2 | 5 | 16.5 | 17 | < 4 | 19.5 |
| METEOR(T-AKR9) | AMERICAN | 4 | 38.4 N | 48.0 W | 00 | 27 | 44 | 10 NM | 02 | 1007.5 | 13.3 | 18.9 | 5 | 8 | 28 | 9 | 29.5 |
| ALBANY | SWEDISH | 4 | 48.5 N | 41.7 W | 00 | 30 | 55 | 5 NM | 03 | 998.0 | 0.0 | 0.0 | | 13 | | | |
| ADM W M CALLAGHAN | AMERICAN | 4 | 55.5 N | 41.1 W | 00 | 28 | 55 | 1 NM | 03 | 987.0 | 5.0 | 2.7 | 8 | 29.5 | | | |
| EXPORT FREEDOM | AMERICAN | 4 | 38.9 N | 47.5 W | 00 | 28 | 45 | 5 NM | 01 | 1008.0 | 10.0 | 19.5 | 6 | 10 | 29 | 9 | 19.5 |
| HOEGH ORRIS | NORWEGIAN | 5 | 40.1 N | 42.8 W | 12 | 26 | 35 | 1 NM | 21 | 1000.0 | 10.8 | 15.0 | XX | 16.5 | 20 | 12 | 42.5 |
| ADM W M CALLAGHAN | AMERICAN | 5 | 48.7 N | 31.0 W | 18 | 21 | 45 | 5 NM | 01 | 976.9 | 1.7 | 2.7 | 4 | 6.5 | 21 | 8 | 19.5 |
| GREAT REPUBLIC | AMERICAN | 6 | 37.6 N | 64.3 W | 12 | 26 | 42 | 5 NM | 02 | 1011.6 | 10.0 | 12.2 | XX | 10 | 30 | 8 | 18 |
| PAUL L FAHRNEY | LIBERIAN | 6 | 37.8 N | 63.0 W | 18 | 29 | M 50 | 5 NM | 29 | 1004.0 | 6.0 | 19.5 | 20 | 32.5 | | | |
| SEALAND RESOURCE | AMERICAN | 6 | 38.4 N | 37.2 W | 18 | 26 | 50 | 5 NM | 18 | 1000.2 | 8.8 | 18.2 | 8 | 21 | 24 | 7 | 28 |
| ALBANY | SWEDISH | 6 | 36.5 N | 61.5 W | 18 | 29 | 46 | 5 NM | 29 | 1002.0 | 13.0 | 19.0 | | 13 | XX | X | 19.5 |
| HOEGH ORRIS | NORWEGIAN | 7 | 42.5 N | 54.6 W | 12 | 25 | 35 | 1 NM | 26 | 994.0 | 7.8 | 10.0 | | | 29 | 7 | 32.5 |
| SEALAND RESOURCE | AMERICAN | 7 | 38.7 N | 58.7 W | 00 | 27 | 50 | 5 NM | 18 | 1003.0 | 7.3 | 15.6 | 7 | 18 | 27 | 7 | 29.5 |
| PAUL L FAHRNEY | LIBERIAN | 7 | 39.0 N | 64.0 W | 00 | 29 | M 45 | 5 NM | 29 | 1008.0 | 9.0 | 19.5 | 15 | 24.5 | | | |
| ALBANY | SWEDISH | 7 | 36.4 N | 63.1 W | 00 | 27 | 46 | 10 NM | 02 | 1010.0 | 13.2 | 15.0 | | 13 | XX | X | 19.5 |
| SEALAND MARKET | AMERICAN | 8 | 36.1 N | 45.0 W | 00 | 26 | 43 | 10 NM | 25 | 1000.5 | 15.5 | 18.7 | | | | | |
| AMER LEGACY | AMERICAN | 9 | 48.7 N | 43.6 W | 12 | 28 | 45 | 5 NM | 26 | 993.9 | 1.1 | 11.7 | 7 | 19.5 | 27 | 9 | 29.5 |
| MOUNT EXPLORER | AMERICAN | 10 | 30.4 N | 78.9 W | 18 | 24 | 45 | 5 NM | 02 | 1009.1 | 15.0 | 24.4 | 6 | 19.5 | 24 | 10 | 24.5 |
| OVERSEAS NATALIE | AMERICAN | 11 | 29.0 N | 76.7 W | 00 | 28 | 48 | 5 NM | 02 | 1010.2 | 18.7 | 22.8 | | | 28 | 8 | 18.5 |
| AMER LEGEND | AMERICAN | 12 | 45.7 N | 24.5 W | 18 | 19 | M 48 | 5 NM | 25 | 1018.5 | 11.7 | 11.1 | 6 | 31 | | | |
| STAGHOUND | AMERICAN | 13 | 48.3 N | 19.8 W | 18 | 31 | 50 | 2 NM | 01 | 999.9 | 10.5 | 11.7 | 4 | 13 | 24 | 8 | 32.5 |
| AMER LEADER | AMERICAN | 13 | 40.6 N | 36.8 W | 00 | 30 | 50 | 2 NM | 00 | 1000.7 | 10.0 | 12.8 | 8 | 18.5 | 30 | 9 | 41 |
| AMER LEGEND | AMERICAN | 13 | 47.4 N | 16.5 W | 18 | 29 | M 60 | 5 NM | 29 | 999.5 | 10.6 | 11.7 | 15 | 39 | | | |
| STAGHOUND | AMERICAN | 14 | 48.1 N | 20.7 W | 00 | 32 | 45 | 5 NM | 01 | 1013.7 | 7.2 | 11.7 | 6 | 11.5 | 25 | 8 | 32.5 |
| AMER LEGEND | AMERICAN | 14 | 47.7 N | 14.9 W | 00 | 29 | M 60 | 5 NM | 25 | 1003.5 | 10.6 | 11.7 | 15 | 39 | | | |
| DOCTOR LYKES | AMERICAN | 14 | 43.9 N | 07.0 W | 18 | 27 | M 45 | 10 NM | 18 | 1022.7 | 11.1 | 12.2 | 8 | 13 | | | |
| EXPORT LEADER | AMERICAN | 15 | 48.7 N | 22.4 W | 18 | 31 | 41 | 5 NM | 03 | 1015.9 | 5.5 | 12.0 | | | 31 | 7 | 24.5 |
| AMER LEGEND | AMERICAN | 15 | 49.3 N | 08.3 W | 00 | 29 | M 55 | 5 NM | 01 | 1009.6 | 10.0 | 9.0 | 10 | 39 | | | |
| ADM W M CALLAGHAN | AMERICAN | 15 | 52.6 N | 33.6 W | 12 | 29 | 50 | 2 NM | 85 | 1011.0 | 0.0 | 3.0 | 5 | 11.5 | 29 | 12 | 19.5 |
| ADM W M CALLAGHAN | AMERICAN | 16 | 54.0 N | 23.8 W | 12 | 29 | 55 | 2 NM | 58 | 1003.0 | 0.0 | 3.0 | 5 | 11.5 | 29 | 12 | 19.5 |
| MARDANGER | NORWEGIAN | 17 | 39.4 N | 62.2 W | 19 | 27 | 50 | 5 NM | 69 | 1000.0 | 13.0 | 20.0 | 8 | 19.5 | 29 | 10 | 24.5 |
| EXXON WASHINGTON | AMERICAN | 17 | 36.1 N | 74.8 W | 12 | 33 | 45 | 10 NM | 02 | 1014.8 | 8.2 | 21.2 | 3 | 14.5 | | | |
| HOUSTON | AMERICAN | 19 | 36.1 N | 73.3 W | 12 | 21 | 45 | 10 NM | 02 | 1020.3 | 7.2 | 7.7 | 5 | 18 | | | |
| NECHES | AMERICAN | 19 | 37.1 N | 70.8 W | 18 | 23 | 45 | 5 NM | 07 | 1021.4 | 10.2 | 21.3 | 5 | 10 | | | |
| LIGHTNING | AMERICAN | 20 | 40.7 N | 61.1 W | 00 | 27 | 43 | 10 NM | 01 | 1016.0 | 11.1 | 14.4 | 12 | 13 | 28 | >13 | 16.5 |
| JUTHLANDIA | LIBERIAN | 20 | 49.2 N | 21.7 W | 12 | 29 | 41 | 5 NM | 03 | 1021.0 | 9.0 | 9.0 | | | | | |
| JUTHLANDIA | LIBERIAN | 22 | 46.9 N | 30.2 W | 00 | 29 | 38 | 5 NM | 03 | 1020.5 | 8.0 | 9.0 | | | | | |
| AMER LEGEND | AMERICAN | 22 | 47.3 N | 13.5 W | 18 | 30 | M 35 | 10 NM | 01 | 1013.0 | 9.4 | 10.6 | 6 | 32.5 | | | |
| AMER ARCHER | AMERICAN | 22 | 47.3 N | 29.3 W | 18 | 32 | 40 | 10 NM | 02 | 1026.0 | 6.7 | 12.3 | 8 | 16.5 | 27 | 10 | 41 |
| AMER ARCHER | AMERICAN | 23 | 46.3 N | 37.4 W | 18 | 22 | 38 | 2 NM | 02 | 1021.0 | 12.2 | 12.8 | 6 | 14.5 | 22 | 10 | 41 |
| AMER LEGEND | AMERICAN | 23 | 47.0 N | 14.8 W | 00 | 30 | M 55 | 10 NM | 01 | 1014.2 | 10.6 | 10.6 | 8 | 32.5 | | | |
| AMER ARCHER | AMERICAN | 24 | 48.2 N | 30.9 W | 00 | 27 | 30 | 2 NM | 60 | 1010.0 | 14.0 | 12.8 | 6 | 13 | 22 | 10 | 41 |
| AMER ARCHER | AMERICAN | 25 | 46.3 N | 34.0 W | 18 | 28 | 40 | 5 NM | 02 | 1015.5 | 1.0 | 4.4 | 6 | 13 | 32 | 10 | 41 |
| AMER ALLIANCE | AMERICAN | 26 | 46.8 N | 31.4 W | 18 | 27 | 40 | 10 NM | 02 | 1010.5 | 8.8 | 12.8 | 7 | 16.5 | 26 | >13 | 37.5 |
| AMER ALLIANCE | AMERICAN | 27 | 48.1 N | 37.9 W | 18 | 30 | 40 | 5 NM | 27 | 1019.1 | 5.0 | 11.7 | 8 | 19.5 | 30 | >13 | 41 |
| SEALAND MARKET | AMERICAN | 28 | 42.2 N | 29.5 W | 00 | 32 | 45 | 10 NM | 02 | 1021.0 | 11.1 | 11.1 | 5 | 11.5 | 29 | 8 | 14.5 |
| EXPORT LEADER | AMERICAN | 28 | 44.1 N | 24.6 W | 18 | 29 | 45 | 10 NM | 18 | 1016.0 | 6.5 | 13.2 | 8 | 29.5 | | | |
| NORTH ATLANTIC OCEAN | | APR. | | | | | | | | | | | | | | | |
| EXPORT LEADER | AMERICAN | 1 | 41.9 N | 52.9 W | 06 | 29 | 65 | 1 NM | 07 | 999.0 | 4.4 | 14.5 | | | | | |
| EXPORT LEADER | AMERICAN | 2 | 41.2 N | 62.2 W | 12 | 23 | 49 | 2 NM | 51 | 1001.7 | 13.0 | 13.5 | | | 24 | 9 | 16.5 |
| SEALAND MARKET | AMERICAN | 3 | 38.6 N | 59.8 W | 18 | 32 | 45 | 10 NM | 15 | 1014.8 | 8.3 | 11.1 | 9 | 19.5 | | | |
| EXPORT LEADER | AMERICAN | 3 | 41.6 N | 44.5 W | 00 | 32 | 45 | 5 NM | 02 | 1011.9 | 3.4 | 8.3 | | | 27 | 8 | 16.5 |
| EXPORT FREEDOM | AMERICAN | 4 | 38.5 N | 42.5 W | 00 | 23 | 45 | 2 NM | 65 | 1002.4 | 15.0 | 16.7 | 4 | 10 | 19 | 9 | 23 |
| AMER LEGEND | AMERICAN | 8 | 39.5 N | 50.6 W | 18 | 19 | M 45 | 5 NM | 62 | 1001.7 | 17.3 | 17.7 | 5 | 21 | 20 | 9 | 21 |
| AMER ARCHER | AMERICAN | 16 | 45.8 N | 39.0 W | 12 | 28 | 50 | 2 NM | 02 | 981.0 | 10.6 | 13.3 | 5 | 19.5 | 28 | 10 | 49 |
| AMER ACCORD | AMERICAN | 16 | 44.8 N | 41.2 W | 00 | 25 | 42 | 10 NM | 25 | 977.8 | 7.8 | 13.3 | | | | | |
| EXPORT FREEDOM | AMERICAN | 20 | 39.9 N | 47.4 W | 00 | 28 | 45 | 2 NM | 61 | 1005.0 | | 15.6 | 6 | 13 | 04 | 10 | 24.3 |
| EXPORT DEFENDER | AMERICAN | 20 | 34.2 N | 50.1 W | 00 | 32 | 41 | 10 NM | 02 | 1007.1 | 15.6 | 18.8 | 4 | 6.5 | 32 | 7 | 16.5 |
| AMER LEGEND | AMERICAN | 21 | 47.5 N | 19.5 W | 00 | 17 | M 45 | 2 NM | 03 | 1000.4 | 11.1 | 11.1 | 6 | 23 | | | |
| NORMACSTAR | AMERICAN | 21 | 37.5 N | 62.9 W | 12 | 18 | 45 | 5 NM | 02 | 1008.1 | 18.9 | 21.1 | | | 18 | < 6 | 16.5 |
| EXPORT PATRIOT | AMERICAN | 21 | 40.8 N | 18.4 W | 12 | 15 | 45 | 2 NM | 01 | 1001.2 | 12.2 | 12.2 | XX | 10 | 17 | 8 | 14.5 |
| MONTICELLO VICTORY | AMERICAN | 23 | 26.2 N | 97.3 W | 12 | 32 | 45 | 900 YD | 04 | 1009.1 | 19.4 | 25.6 | 2 | 3 | 09 | < 6 | 3 |
| SAN JUAN | AMERICAN | 27 | 38.2 N | 73.3 W | 18 | 02 | 45 | 1 NM | | 999.6 | 8.9 | 8.4 | 8 | 19.5 | | | |
| SANTA LUCIA | AMERICAN | 27 | 36.7 N | 74.7 W | 19 | 01 | 45 | 2 NM | 60 | 997.5 | 6.3 | 8.3 | 6 | 23 | | | |
| NORIL ENGINEER | LIBERIAN | 28 | 31.6 N | 70.8 W | 18 | 31 | 42 | 10 NM | 01 | 1007.8 | 17.5 | 19.0 | | | 31 | 10 | 13 |
| SANTA LUCIA | AMERICAN | 28 | 37.8 N | 74.6 W | 01 | 36 | 50 | 2 NM | 02 | 1004.0 | 6.7 | 6.7 | 6 | 19.5 | 36 | 6 | 41 |
| NINA U | LIBERIAN | 28 | 38.5 N | 71.0 W | 00 | 33 | 43 | 4 NM | 02 | 996.5 | 14.5 | 25.0 | 5 | 18 | 09 | >13 | 29.5 |
| ARCO PRESTIGE | AMERICAN | 28 | 37.8 N | 72.8 W | 00 | 31 | 45 | 5 NM | 02 | 1002.4 | 7.2 | 14.4 | 5 | 18 | | | |
| DORIC | PANAMANIAN | 28 | 36.9 N | 69.3 W | 18 | 32 | M 50 | 10 NM | 92 | 999.5 | 14.0 | 20.0 | 8 | 19.5 | | | |
| NORTH ATLANTIC OCEAN | | APR. | | | | | | | | | | | | | | | |
| ENVIRONMENTAL BUOYS | | | | | | | | | | | | | | | | | |
| 41002 | AMERICAN | 19 | 32.3 N | 75.3 W | 09 | 19 | M 43 | | | 1010.1 | 19.2 | 21.1 | 7 | 10 | | | |
| 44004 | AMERICAN | 27 | 39.0 N | 70.0 W | 21 | 03 | M 44 | | | 995.8 | 7.9 | 17.3 | | | | | |
| 44004 | AMERICAN | 28 | 39.0 N | 70.0 W | 00 | 03 | M 46 | | | 993.5 | 7.2 | 16.7 | | | | | |

* Direction for sea waves same as wind direction
X Direction or period of waves indeterminate
M Measured wind

NOTE: The observations are selected from those with winds ≥ 35 kn or waves ≥ 25 ft from May through August (≥ 41 kn or ≥ 33 ft, September through April). In cases where a ship reported more than one observation a day with such values, the one with the highest wind speed was selected.

# Selected Gale and Wave Observations, North Pacific

## March and April 1978

| Vessel | Nationality | Date | Position of Ship | | Time | Wind | | Visibility | Present Weather | Pressure | Temperature °C | | Sea Waves* | | Swell Waves | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Lat. | Long. | GMT | Dir. | Speed | n. mi. | code | mb. | Air | Sea | Period | Height | Dir. | Period | Height |
| NORTH PACIFIC OCEAN | | ZDA | deg. | deg. | | 10° | kt. | | | | | | sec. | ft. | 10° | sec. | ft. |
| HONGKONG PHOENIX | SINGAPORE | 1 | 29.5 N | 147.6 E | 12 | 27 | 45 | 2 NM | 63 | 1013.5 | 13.0 | 19.0 | 5 | 11.5 | 26 | 10 | 14.5 |
| ASIAN ASSURANCE | LIBERIAN | 1 | 35. N | 153.5 E | 12 | 25 N | 52 | .5 NM | 10 | 997.0 | 13.5 | 14.0 | | | 25 | >13 | 23 |
| ASIA BRAVERY | LIBERIAN | 1 | 44.6 N | 177.5 W | 00 | 30 N | 50 | 2 NM | 03 | 985.6 | 3.0 | 9.0 | 7 | 29.5 | | | |
| SEALAND COMMERCE | AMERICAN | 1 | 49.5 N | 154.6 W | 00 | 10 | 50 | 1 NM | 60 | 980.9 | 5.0 | 2.2 | 12 | 29.5 | | | |
| PRES TRUMAN | AMERICAN | 1 | 38.1 N | 140.6 E | 12 | 27 | 80 | 2 NM | 28 | 1002.0 | 8.0 | 6.7 | 7 | 16.5 | 27 | 10 | 39 |
| ORIENTAL LEADER | LIBERIAN | 1 | 32.4 N | 141.6 E | 12 | 32 N | 50 | 5 NM | 50 | 1013.9 | 12.0 | 19.0 | | | | | |
| PRES ROOSEVELT | AMERICAN | 1 | 47.9 N | 140.6 E | 00 | 27 | 75 | 4 NM | 02 | 996.6 | 6.4 | 10.6 | 9 | 29.5 | | | |
| LAUREL | LIBERIAN | 2 | 29.5 N | 174.1 E | 12 | 19 N | 43 | 5 NM | 03 | 1006.0 | 15.0 | 16.0 | 2 | 6.5 | 23 | < 6 | 8 |
| ASIAN ASSURANCE | LIBERIAN | 2 | 35.0 N | 152.5 E | 00 | 29 N | 55 | 1 NM | 80 | 1006.0 | 8.5 | 17.0 | 13 | 18 | 29 | >13 | 26 |
| OGDEN CONGO | LIBERIAN | 2 | 35.4 N | 155.3 E | 12 | 28 N | 05 | 2 NM | 02 | 1006.1 | 7.0 | 12.0 | | | 29 | < 6 | 21 |
| PACIFIC SECRY | LIBERIAN | 2 | 32.5 N | 134.5 W | 00 | 22 | 45 | < 50 | VD | 998.3 | 14.0 | 16.0 | | | 32 | < 6 | 24.5 |
| PRES TRUMAN | AMERICAN | 2 | 38.5 N | 140.2 E | 01 | 32 | 00 | 2 NM | 26 | 1010.8 | 0.0 | 10.0 | 6 | 18 | 32 | 11 | 54 |
| INDIAN MAIL | AMERICAN | 3 | 43.5 N | 151.6 E | 00 | 34 | 47 | 2 NM | 28 | 999.0 | - 1.7 | 1.5 | 5 | 13 | 31 | 7 | 28 |
| WORLD RUBY | LIBERIAN | 3 | 33.0 N | 140.8 W | 12 | 32 N | 00 | 2 NM | 50 | 1009.0 | 12.0 | 15.0 | XX | 19.5 | 30 | 9 | 29.5 |
| ASIAN ASSURANCE | LIBERIAN | 3 | 35.0 N | 147.9 E | 00 | 32 N | 46 | 2 NM | 03 | 1015.0 | 8.5 | 17.0 | 12 | 18 | 32 | >13 | 41 |
| OGDEN CONGO | LIBERIAN | 3 | 35.3 N | 152.9 E | 00 | 30 N | 55 | 2 NM | 02 | 1012.5 | 10.0 | 16.0 | | | 30 | < 6 | 21 |
| HAWAIIAN ENTERPRISE | AMERICAN | 4 | 29.8 N | 135.2 W | 00 | 23 | 45 | 4 NM | 18 | 999.7 | 13.9 | 17.8 | 10 | 11.5 | 26 | 9 | 16.5 |
| LURLINE | AMERICAN | 5 | 35.5 N | 129.6 W | 00 | 31 | 45 | 4 NM | 81 | 997.0 | 14.4 | 14.4 | 8 | 13 | 27 | 12 | 19.5 |
| SEVILLAN REEFER | LIBERIAN | 5 | 31.8 N | 154.4 E | 12 | 16 | 45 | 4 NM | 02 | 1005.6 | 16.2 | 17.0 | 6 | 13 | XX | X | 8 |
| PRES MONROE | AMERICAN | 5 | 33.8 N | 145.5 E | 00 | 02 | 55 | 2 NM | 18 | 1003.8 | 11.1 | 15.6 | 6 | 16.5 | | | |
| SEATRAIN LEXINGTON | GERMAN | 5 | 29.3 N | 171.0 W | 00 | 27 | 45 | 10 NM | 02 | 1008.1 | 15.5 | 17.0 | 8 | 13 | | | |
| OGDEN JORDAN | LIBERIAN | 6 | 34.7 N | 154.1 E | 18 | 30 N | 47 | 4 NM | 65 | 1009.5 | 9.5 | 16.0 | | | | | |
| PRESIDENT MADISON | AMERICAN | 6 | 46.4 N | 154.5 E | 12 | 34 N | 45 | 10 NM | 71 | 1004.5 | 0.0 | 0.0 | 5 | 10 | | | |
| AMERICA MARU | JAPANESE | 6 | 47.1 N | 141.7 W | 18 | 18 N | 42 | .25 NM | | 984.5 | 6.0 | 10.0 | 2 | 6.5 | 18 | 10 | 16.5 |
| PRESIDENT MADISON | AMERICAN | 7 | 43.8 N | 140.2 E | 00 | 29 N | 45 | > 25 NM | 02 | 1015.0 | 3.4 | 1.1 | 5 | 10 | | | |
| MIDAS SEINE | LIBERIAN | 8 | 38.9 N | 146.5 E | 23 | 25 N | 42 | 10 NM | 93 | 1001.0 | 6.5 | 10.0 | 12 | 13 | | | |
| AQUILA | AMERICAN | 9 | 54.0 N | 136.0 W | 06 | 18 | 45 | 4 NM | 00 | 1006.1 | 3.3 | 5.5 | | | | | |
| PRES JOHNSON | AMERICAN | 9 | 54.1 N | 162.5 W | 01 | 32 | 45 | 2 NM | 10 | 981.5 | - 1.1 | 3.9 | | | 32 | 8 | 16.5 |
| ADRIAN MAERSK | DANISH | 10 | 37.0 N | 145.5 E | 18 | 16 | 45 | 2 NM | 63 | 989.5 | 15.5 | | | | | | |
| NEW ENGLAND HUNTER | LIBERIAN | 10 | 28.2 N | 138.6 E | 18 | 25 | 47 | 4 NM | 02 | 1007.5 | 17.5 | 21.0 | | | | | |
| ARCO JUNEAU | AMERICAN | 11 | 49.1 N | 127.0 W | 18 | 32 N | 45 | 10 NM | 03 | 1014.1 | 8.9 | 5.6 | 4 | 5 | 32 | 11 | 11.5 |
| PRES JEFFERSON | AMERICAN | 11 | 41.2 N | 153.4 E | 00 | 15 | 45 | 10 NM | 02 | 1006.8 | 7.8 | 8.9 | 5 | 11.5 | 18 | 8 | 13 |
| VAN ENTERPRISE | LIBERIAN | 11 | 39.1 N | 138.2 E | 06 | 26 N | 54 | 1 NM | 84 | 999.0 | 1.5 | 7.0 | | | 26 | 13 | 32.5 |
| AMERICAN INDEPENDENCE | AMERICAN | 12 | 34.1 N | 121.1 W | 18 | 33 N | 45 | 5 NM | 07 | 1010.2 | 12.3 | 16.7 | 6 | 10 | 33 | 6 | 19.5 |
| GREEN ECHO | LIBERIAN | 12 | 53.8 N | 165.3 W | 12 | 14 N | 50 | 2 NM | 51 | 974.0 | 3.0 | 2.0 | 12 | 24.5 | | | |
| TOKYO RAINBOW | JAPANESE | 12 | 52.6 N | 170.3 W | 06 | 27 N | 42 | 5 NM | 50 | 977.5 | 2.0 | 2.0 | 5 | 6.5 | 23 | 6 | 10 |
| AMERICAN INDEPENDENCE | AMERICAN | 13 | 34.6 N | 121.6 W | 00 | 32 N | 46 | 5 NM | 07 | 1012.5 | 14.0 | 16.5 | 7 | 11.5 | 33 | 7 | 23 |
| GREEN ECHO | LIBERIAN | 16 | 48.5 N | 162.5 E | 12 | 20 N | 52 | .5 NM | | 985.0 | 2.0 | 2.0 | 9 | 14.5 | | | |
| GREEN ECHO | LIBERIAN | 17 | 47.9 N | 160.2 E | 01 | 26 N | 52 | .5 NM | | 993.0 | 2.0 | 0.1 | 9 | 14.5 | | | |
| BULLY TURMAN | AMERICAN | 18 | 13.6 N | 94.6 W | 18 | 36 N | 45 | 5 NM | 02 | 1015.0 | 23.3 | 27.7 | 5 | 14.5 | 36 | 8 | 28 |
| GOLDEN ARROW | JAPANESE | 18 | 42.5 N | 178.9 W | 00 | 23 N | 48 | 1 NM | 10 | 989.0 | 9.0 | 8.0 | 3 | 6.5 | 24 | 7 | 13 |
| PRUDENTIAL OCEAN JET | AMERICAN | 18 | 16.0 N | 95.0 W | 00 | 36 | 70 | 5 NM | 02 | 1017.0 | 18.4 | 26.7 | 3 | 13 | | | |
| EASTERN PACIFIC | JAPANESE | 19 | 49.1 N | 168.7 W | 00 | 25 N | 81 | 1 NM | | 999.9 | 3.0 | 3.0 | 7 | 13 | 23 | 12 | 29.5 |
| SEPTA | LIBERIAN | 19 | 49.4 N | 160.0 E | 00 | 24 N | 45 | 5 NM | 05 | 1002.0 | 9.0 | 4.0 | 6 | 10 | | | |
| UNIVERSE KURE | LIBERIAN | 20 | 37.6 N | 161.4 E | 12 | 25 N | 48 | 5 NM | 05 | 999.2 | 10.5 | 14.0 | 7 | 16.5 | 20 | 8 | 23 |
| CRESSINA | PANAMANIAN | 20 | 42.4 N | 153.5 E | 18 | 32 N | 47 | 1 NM | 05 | 996.0 | 0.5 | | 8 | 26 | | | |
| OGDEN CONGO | LIBERIAN | 21 | 39.9 N | 157.0 W | 18 | 30 N | 48 | 5 NM | 02 | 1013.5 | 8.0 | 10.0 | | | 31 | < 6 | 10 |
| UNIVERSE KURE | LIBERIAN | 21 | 37.4 N | 160.0 E | 06 | 27 N | 48 | 10 NM | 25 | 1006.3 | 7.8 | 12.8 | 7 | 19.5 | 28 | 8 | 24.5 |
| SHUNKIND | LIBERIAN | 21 | 54.0 N | 171.1 E | 18 | 11 N | 42 | 5 NM | 07 | 995.0 | 2.0 | 4.0 | 6 | 23 | 11 | 8 | 39 |
| GREEN AUKLET | PANAMANIAN | 21 | 47.1 N | 158.8 E | 12 | 33 N | 45 | .25 NM | 42 | 990.0 | - 0.5 | 1.0 | | | 33 | 10 | 23 |
| CHESTNUT HILL | AMERICAN | 21 | 40.1 N | 136.4 W | 00 | 24 | 45 | 1 NM | 28 | 998.8 | 8.3 | 10.0 | 8 | 14.5 | 23 | 11 | 18 |
| MARIA TOPIC | LIBERIAN | 22 | 37.4 N | 144.9 E | 18 | 04 | 48 | .25 NM | | 990.0 | 1.0 | 8.0 | 10 | 23 | | | |
| OGDEN CONGO | LIBERIAN | 22 | 39.8 N | 154.9 W | 00 | 30 N | 45 | 2 NM | 02 | 1012.0 | 8.5 | 10.0 | 7 | 8 | 30 | 6 | 11.5 |
| SHUNKIND | LIBERIAN | 22 | 53.9 N | 168.3 E | 00 | 12 N | 36 | 2 NM | 02 | 989.0 | 4.0 | 4.0 | 6 | 23 | 13 | 8 | 32.5 |
| UNIVERSE KURE | LIBERIAN | 22 | 36.5 N | 153.5 E | 18 | 23 N | 48 | 5 NM | 21 | 986.0 | 15.0 | 15.6 | 6 | 16.5 | 23 | 8 | 19.5 |
| COLORADO | AMERICAN | 22 | 28.6 N | 145.9 E | 06 | 18 | 45 | 2 NM | 60 | 1001.0 | 21.1 | 17.8 | 6 | 14.5 | 18 | 6 | 18 |
| UNIVERSE KURE | LIBERIAN | 23 | 36.5 N | 152.5 E | 06 | 29 N | 47 | 10 NM | 02 | 995.0 | 10.0 | 13.0 | 7 | 16.5 | 29 | 9 | 24.5 |
| MARIA TOPIC | LIBERIAN | 23 | 37.8 N | 146.2 E | 00 | 04 | 45 | .25 NM | 58 | 987.0 | 4.0 | 10.0 | 12 | 23 | | | |
| LINDANA | LIBERIAN | 25 | 46.6 N | 163.5 W | 18 | 27 N | 46 | 2 NM | 03 | 988.2 | 5.2 | | 7 | 11.5 | | | |
| PRES JEFFERSON | AMERICAN | 25 | 52.9 N | 171.7 E | 01 | 18 | 55 | 5 NM | 50 | 969.0 | 3.3 | 2.2 | 7 | 19.5 | 18 | 7 | 47.5 |
| LIONS GATE BRIDGE | JAPANESE | 26 | 48.6 N | 157.9 W | 18 | 26 N | 56 | 5 NM | 61 | 982.7 | 4.5 | 5.0 | 6 | 14.5 | 28 | 12 | 26 |
| LINDANA | LIBERIAN | 26 | 46.5 N | 163.9 W | 00 | 27 N | 50 | 2 NM | 03 | 991.5 | 6.0 | | 8 | 16.5 | | | |
| PRES JEFFERSON | AMERICAN | 26 | 49.1 N | 167.3 E | 01 | 26 | 45 | 5 NM | 00 | 994.5 | 4.4 | 1.1 | 5 | 18 | 28 | 9 | 32.5 |
| LIONS GATE BRIDGE | JAPANESE | 27 | 48.9 N | 154.8 W | 00 | 25 N | 43 | 2 NM | 61 | 983.9 | 3.0 | 5.0 | 6 | 14.5 | 25 | 12 | 26 |
| ORIENTAL LEADER | LIBERIAN | 28 | 36.9 N | 172.9 E | 06 | 29 N | 48 | 2 NM | 51 | 994.2 | 12.0 | 13.0 | 8 | 16.5 | | | |
| ANCO DUKE | BRITISH | 28 | 39.6 N | 176.6 W | 06 | 17 | 46 | 1 NM | 07 | 1001.0 | 12.0 | 11.0 | 7 | 16.5 | 17 | 9 | 24.5 |
| STREAM RUDDER | LIBERIAN | 28 | 33.2 N | 144.3 E | 12 | 18 N | 45 | 2 NM | 01 | 1002.0 | 14.5 | 16.5 | | | | | |
| PRES JEFFERSON | AMERICAN | 28 | 36.5 N | 143.7 E | 12 | 16 | 45 | 2 NM | 82 | 997.0 | 12.2 | 10.0 | 4 | 13 | 30 | 9 | 16.5 |
| PRES TAFT | AMERICAN | 28 | 38.0 N | 179.4 W | 00 | 17 | 45 | 2 NM | 07 | 995.7 | 13.3 | 11.7 | 3 | 16.5 | 17 | >13 | 32.5 |
| ARCO FAIRBANKS | AMERICAN | 29 | 50.8 N | 178.0 W | 00 | 09 | N 44 | 5 NM | 07 | 1000.0 | 4.5 | 1.2 | 5 | 13 | | | |
| GOLDENROD | LIBERIAN | 29 | 31.6 N | 163.8 E | 18 | 17 | N 41 | 2 NM | 02 | 1004.0 | 16.0 | 17.0 | 6 | 6.5 | 17 | 12 | 14.5 |
| ASIAN ASSURANCE | LIBERIAN | 29 | 44.9 N | 155.7 E | 23 | 05 | N 42 | 50 YD | 47 | 994.6 | - 1.5 | 1.0 | 10 | 11.5 | 05 | 12 | 24.5 |
| QUEENS WAY BRIDGE | JAPANESE | 29 | 42.1 N | 176.8 W | 00 | 23 | N 43 | 1 NM | 80 | 986.3 | 7.0 | 8.5 | 6 | 13 | 22 | 12 | 19.5 |
| ANCO DUKE | BRITISH | 29 | 38.4 N | 179.6 E | 18 | 27 | 47 | 5 NM | 81 | 1007.0 | 7.2 | 12.2 | 8 | 24.5 | 27 | 11 | 34.5 |
| OCEAN BRAVE | JAPANESE | 29 | 41.6 N | 175.3 W | 18 | 25 | N 45 | 5 NM | 80 | 992.2 | 6.4 | 8.0 | 6 | 14.5 | | | |
| MARIA TOPIC | LIBERIAN | 29 | 48.1 N | 161.5 W | 18 | 14 | 45 | 1 NM | 63 | 987.0 | 4.0 | 4.0 | 10 | 19.5 | | | |
| SEATRAIN CONCORD | FRENCH | 30 | 30.9 N | 165.8 E | 00 | 18 | N 44 | 1 NM | 63 | 1004.5 | 17.4 | 17.0 | 5 | 13.5 | | | |
| ANCO DUKE | BRITISH | 30 | 38.7 N | 179.4 E | 01 | 27 | 47 | 10 NM | 81 | 1013.0 | 7.8 | 12.5 | 8 | 24.5 | 27 | 11 | 32.5 |
| VIOLET | LIBERIAN | 30 | 36.8 N | 133.6 W | 00 | 35 | N 41 | 5 NM | 81 | 1011.0 | 10.0 | 10.0 | 5 | 8 | 32 | 8 | 11.5 |
| SEALAND TRADE | AMERICAN | 30 | 35.1 N | 176.0 W | 00 | 27 | 40 | 10 NM | 02 | 1018.3 | 12.2 | 12.8 | 4 | 6.5 | 29 | 9 | 32.5 |
| JAPAN BEAR | AMERICAN | 30 | 33.2 N | 136.3 W | 18 | 36 | N 46 | 10 NM | 02 | 1020.0 | 13.9 | 15.0 | | | 36 | 8 | 19.5 |
| LINDANA | LIBERIAN | 31 | 43.2 N | 165.8 E | 00 | 27 | N 48 | 2 NM | 68 | 992.8 | 4.3 | | 8 | 16.5 | 27 | 7 | 19.5 |
| ILLINOIS | AMERICAN | 31 | 35.9 N | 129.4 W | 00 | 01 | 45 | 5 NM | 15 | 1008.4 | 12.2 | 13.3 | 8 | 23 | 36 | 10 | 29.5 |
| NEW ENGLAND HUNTER | LIBERIAN | 31 | 30.5 N | 134.5 W | 00 | 01 | 41 | 10 NM | 02 | 1016.8 | 16.5 | 18.0 | 8 | 11.5 | | | |
| ENVIRONMENTAL BUOYS | | | | | | | | | | | | | | | | | |
| 46003 | AMERICAN | 9 | 52.0 N | 156.0 W | 03 | 26 | M 42 | | | 984.6 | 2.2 | 3.0 | 9 | 14.5 | | | |
| NORTH PACIFIC OCEAN | | APR. | | | | | | | | | | | | | | | |
| SEALAND TRADE | AMERICAN | 1 | 35.1 N | 161.4 E | 00 | 18 | 45 | 5 NM | 03 | 990.0 | 15.6 | 13.9 | 4 | 6.5 | 20 | 10 | 13 |
| PRES ROOSEVELT | AMERICAN | 2 | 33.2 N | 142.4 E | 12 | 11 | 43 | 2 NM | 61 | 1013.6 | 11.3 | 17.8 | 4 | 11.5 | 10 | 8 | 14.5 |
| DON CARLOS | SWEDISH | 2 | 52.2 N | 173.9 E | 12 | 22 | 50 | .25 NM | 61 | 997.4 | 1.3 | | 8 | 41 | | | |

| Vessel | Nationality | Date | Position of Ship | | Time | Wind | | Visibility | Present Weather | Pressure | Temperature °C | | Sea Waves* | | Swell Waves | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NORTH PACIFIC OCEAN | | APR. | Lat. deg. | Long. deg. | GMT | Dir. 10° | Speed kt. | n. mi. | code | mb. | Air | Sea | Period sec. | Height ft. | Dir. 10° | Period sec. | Height ft. |
| FRIENDSHIP | LIBERIAN | 2 | 52.6 N | 177.8 E | 12 | 20 | 41 | 1 | FM | 07 | 978.0 | 2.5 | 4.0 | | | | |
| MONTIGNY | LIBERIAN | 2 | 52.9 N | 179.0 E | 18 | 19 | M 42 | 4 | FM | 03 | 981.5 | 1.0 | 1.0 | 6 | 19.5 | | |
| PRESIDENT MADISON | AMERICAN | 3 | 49.2 N | 154.0 E | 00 | 29 | M 45 | 10 | FM | 85 | 998.8 | - 5.6 | 1.7 | 8 | 16.5 | | |
| PRES ROOSEVELT | AMERICAN | 3 | 53.6 N | 161.9 E | 00 | 13 | 48 | 9 | FM | 21 | 1007.0 | 12.2 | 17.2 | 7 | 16.5 | 16 | 8 | 18 |
| FRIENDSHIP | LIBERIAN | 3 | 52.1 N | 176.4 E | 06 | 24 | 48 | 9 | FM | 07 | 970.0 | 2.0 | 5.0 | | | 24 | >13 | 23 |
| CHEVRON OREGON | AMERICAN | 3 | 48.4 N | 126.7 W | 18 | 16 | M 42 | 4 | FM | 81 | 1008.5 | 11.2 | | 4 | 5 | 18 | 8 | 10 |
| DON CARLOS | SWEDISH | 3 | 51.4 N | 171.9 E | 00 | 27 | 46 | 9 | FM | 87 | 997.8 | 3.0 | | 12 | 36 | | | |
| PRES VAN BUREN | AMERICAN | 3 | 54.5 N | 145.6 E | 18 | 30 | 60 | 9 | FM | 03 | 993.0 | 15.0 | 15.0 | 6 | 24.5 | 30 | 9 | 36 |
| MONTIGNY | LIBERIAN | 3 | 52.7 N | 176.1 E | 06 | 21 | M 45 | 1 | FM | 84 | 971.0 | 2.0 | 0.0 | 9 | 24.5 | | | |
| PIONEER CRUSADER | AMERICAN | 3 | 52.9 N | 149.2 E | 06 | 15 | 41 | 1 | FM | 05 | 1002.0 | 15.0 | 16.7 | 8 | 10 | | | |
| ORIENTAL EXECUTIVE | LIBERIAN | 3 | 34.8 N | 144.7 E | 00 | 14 | M 30 | 9 | FM | 07 | 996.0 | 14.5 | 20.0 | 7 | 29.5 | 13 | 7 | 39 |
| VAN CONQUEROR | LIBERIAN | 3 | 50.2 N | 176.0 E | 12 | 25 | M 43 | 4 | FM | 01 | 983.0 | 1.0 | 3.0 | | | | | |
| PRES VAN BUREN | AMERICAN | 4 | 54.5 N | 144.6 E | 00 | 31 | 60 | 10 | FM | 02 | 1004.0 | 12.3 | 15.0 | 9 | 32.5 | | | |
| VAN CONQUEROR | LIBERIAN | 4 | 49.8 N | 174.4 E | 00 | 25 | M 43 | 9 | FM | 02 | 989.0 | 2.0 | 6.0 | | | | | |
| PIONEER CRUSADER | AMERICAN | 4 | 51.7 N | 150.7 E | 12 | 28 | 51 | 9 | FM | 25 | 1006.7 | 14.4 | 16.1 | 8 | 39 | | | |
| ORIENTAL STATESMAN | LIBERIAN | 4 | 33.9 N | 148.9 E | 06 | 30 | M 48 | 9 | FM | 02 | 1001.0 | 14.0 | 14.5 | 8 | 16.5 | 30 | 12 | 23 |
| MONTIGNY | LIBERIAN | 4 | 51.5 N | 175.3 E | 00 | 25 | M 41 | 9 | FM | 83 | 975.0 | 2.0 | 1.5 | 9 | 24.5 | | | |
| PRES ROOSEVELT | AMERICAN | 4 | 35.3 N | 163.8 E | 18 | 26 | 56 | 9 | FM | 00 | 987.8 | 13.9 | 16.2 | 7 | 19.5 | 25 | 11 | 34.5 |
| PACMERCHANT | LIBERIAN | 4 | 42.2 N | 167.3 E | 00 | 00 | M 49 | .25 | FM | 69 | 989.0 | 2.2 | 8.0 | | | 00 | 9 | 11.5 |
| PACIFIC WING | PANAMANIAN | 4 | 35.7 N | 163.2 E | 00 | 15 | M 48 | 1 | FM | 41 | 1000.5 | 14.0 | 15.0 | | | 14 | 8 | 14.5 |
| DON CARLOS | SWEDISH | 4 | 50.4 N | 167.1 E | 00 | 29 | 36 | 9 | FM | 00 | 999.7 | 3.0 | | 10 | 32.5 | | | |
| ANCO DUKE | BRITISH | 4 | 36.5 N | 154.8 E | 12 | 32 | 56 | 9 | FM | 82 | 990.5 | 8.3 | 12.2 | 7 | 24.5 | 32 | 10 | 29.5 |
| HERMINA | LIBERIAN | 4 | 34.1 N | 153.7 E | 06 | 24 | 45 | 9 | FM | 18 | 991.0 | 13.0 | 18.0 | 8 | 16.5 | 24 | 11 | 19.5 |
| VIOLET | LIBERIAN | 5 | 37.6 N | 175.2 E | 06 | 14 | M 42 | 9 | FM | 05 | 988.0 | 14.0 | 13.0 | 5 | 11.5 | 20 | >13 | 13 |
| PIONEER CRUSADER | AMERICAN | 5 | 51.2 N | 139.8 E | 00 | 32 | 45 | 9 | FM | 01 | 1017.3 | 20.6 | 10.1 | 8 | 41 | | | |
| PRES ROOSEVELT | AMERICAN | 5 | 35.0 N | 166.2 E | 00 | 27 | 45 | 9 | FM | 18 | 993.0 | 13.0 | 13.6 | 7 | 19.5 | 27 | 12 | 34.5 |
| AMERICA MARU | JAPANESE | 5 | 47.3 N | 136.9 W | 06 | 28 | M 45 | 5 | FM | 21 | 997.0 | 6.0 | 10.0 | 6 | 6.5 | 28 | 8 | 21 |
| AQUILA | AMERICAN | 5 | 47.3 N | 132.0 W | 09 | 27 | 45 | 5 | FM | 80 | 994.2 | 5.6 | 9.5 | | | 25 | 9 | 19.5 |
| JAPAN BEAR | AMERICAN | 5 | 43.2 N | 178.3 W | 06 | 17 | M 37 | 2 | FM | 28 | 987.5 | 8.9 | 6.7 | 10 | 41 | | | |
| ANCO DUKE | BRITISH | 6 | 34.9 N | 143.5 E | 12 | 19 | 47 | 9 | FM | 50 | 999.0 | 14.0 | 15.8 | 6 | 19.5 | 19 | 6 | 24.5 |
| SEALAND FINANCE | AMERICAN | 6 | 52.9 N | 179.3 E | 00 | 36 | 45 | 10 | FM | 01 | 974.5 | 3.9 | 1.7 | 4 | 6.5 | | | |
| WYOMING | AMERICAN | 7 | 34.9 N | 153.4 E | 06 | 16 | 45 | .5 | FM | 45 | 1003.0 | 13.2 | 13.0 | 9 | 16.5 | | | |
| TOKYO RAINBOW | JAPANESE | 7 | 34.5 N | 139.1 E | 06 | 04 | M 45 | 5 | FM | 05 | 1004.5 | 14.5 | 17.0 | 3 | 3 | 04 | 12 | 3 |
| VAN CONQUEROR | LIBERIAN | 7 | 42.5 N | 153.0 E | 06 | 13 | M 46 | .5 | FM | 63 | 993.0 | 9.0 | 3.0 | | | | | |
| LONG BEACH | PANAMANIAN | 8 | 54.2 N | 161.0 W | 00 | 25 | N 47 | 2 | FM | 15 | 992.0 | 7.5 | 9.0 | 4 | 14.5 | 23 | < 6 | 23 |
| WESTWARD VENTURE | AMERICAN | 10 | 54.7 N | 137.7 W | 00 | 16 | M 35 | 9 | FM | 21 | 996.0 | 7.8 | 7.7 | 12 | 16.5 | | | |
| MOBIL MERIDIAN | AMERICAN | 10 | 36.5 N | 139.4 W | 12 | 30 | 50 | 10 | FM | 50 | 1008.8 | 4.4 | 5.6 | | 10 | | | |
| MOBIL ARCTIC | AMERICAN | 10 | 58.8 N | 147.0 W | 18 | 27 | 45 | 5 | FM | 01 | 1005.2 | 2.5 | 2.6 | 7 | 16.5 | 27 | >13 | 16.5 |
| BRINTON LYKES | AMERICAN | 11 | 33.2 N | 161.8 E | 18 | 30 | 41 | 10 | FM | 01 | 1008.8 | 12.3 | 15.0 | | | 30 | 8 | 21 |
| VAN ENTERPRISE | LIBERIAN | 12 | 33.2 N | 149.5 E | 12 | 12 | M 42 | 9 | FM | 03 | 1005.5 | 13.0 | 13.0 | | | 12 | < 6 | 23 |
| NORSE PILOT | BRITISH | 12 | 36.1 N | 172.4 E | 18 | 28 | M 45 | 10 | FM | 03 | 1010.0 | 11.0 | 7.0 | 9 | 32.5 | | | |
| ARCO ANCHORAGE | AMERICAN | 13 | 39.1 N | 125.0 W | 12 | 34 | M 45 | 9 | FM | 03 | 1012.0 | 11.2 | 10.0 | | | 36 | 11 | 16.5 |
| PRES PIERCE | AMERICAN | 14 | 52.8 N | 179.6 E | 06 | 26 | M 50 | 10 | FM | 02 | 1000.3 | 4.5 | 2.8 | 5 | 11.5 | 26 | 8 | 18 |
| FRIENDSHIP | LIBERIAN | 15 | 41.5 N | 173.5 E | 12 | 15 | 43 | 1 | FM | 10 | 999.5 | 8.0 | 10.0 | 11 | 13 | 17 | 12 | 19.5 |
| PRESIDENT MADISON | AMERICAN | 15 | 39.0 N | 163.6 E | 18 | 29 | M 43 | 5 | FM | 02 | 1004.2 | 6.1 | 10.6 | 9 | 23 | 36 | >13 | 16.5 |
| GOLDEN MARINER | PANAMANIAN | 17 | 47.0 N | 180.5 E | 09 | 14 | M 45 | .5 | FM | 05 | 986.0 | 2.0 | 1.0 | 5 | 8 | | | |
| ATLANTIC HIGHWAY | LIBERIAN | 18 | 48.3 N | 167.3 E | 00 | 27 | M 40 | .5 | FM | | 1003.0 | 4.0 | 1.0 | | | 27 | 7 | 32.5 |
| ALSTER EXPRESS | GERMAN | 18 | 51.1 N | 164.5 E | 03 | 27 | 44 | 10 | FM | 02 | 996.5 | 0.5 | 1.0 | | 10 | 27 | | 19.5 |
| VAN WARRIOR | LIBERIAN | 18 | 47.5 N | 170.6 E | 00 | 26 | 60 | 2 | FM | 01 | 1003.6 | 6.5 | 6.0 | 6 | 29.5 | 25 | 7 | 41 |
| VAN WARRIOR | LIBERIAN | 19 | 46.4 N | 165.6 E | 00 | 28 | 50 | 9 | FM | 02 | 1019.0 | 7.3 | 6.0 | 5 | 26 | 27 | 7 | 32.5 |
| BRINTON LYKES | AMERICAN | 23 | 21.1 N | 171.3 E | 06 | 15 | 55 | 30 | FU | 04 | 993.5 | 23.5 | 30.0 | 5 | 16.5 | XX | X | 36 |
| PRES TAFT | AMERICAN | 25 | 10.8 N | 122.7 E | 09 | 21 | 60 | 1 | FM | 16 | 1002.0 | 23.9 | 23.8 | | | 19 | 6 | 24.5 |
| SEATRAIN PRINCETON | GERMAN | 26 | 40.0 N | 135.4 E | 18 | 27 | 44 | 9 | FM | 18 | 999.4 | 5.0 | 9.0 | 8 | 19.5 | 28 | >13 | 26 |
| SEATRAIN PRINCETON | GERMAN | 27 | 40.0 N | 137.2 E | 00 | 27 | 44 | 9 | FM | 02 | 1003.3 | 8.0 | 10.4 | 12 | 29.5 | | | |
| JUTHLANDIA | LIBERIAN | 28 | 43.1 N | 160.7 E | 06 | 29 | 42 | 9 | FM | 05 | 1008.0 | 4.9 | 2.5 | | | | | |
| NORTH PACIFIC OCEAN | | APR. | | | | | | | | | | | | | | | | |
| ENVIRONMENTAL BUOYS | | | | | | | | | | | | | | | | | | |
| 46005 | AMERICAN | 5 | 46.0 N | 131.0 W | 12 | 25 | M 43 | | | | 1001.2 | 6.1 | 8.9 | 11 | 21 | | | |

* Direction for sea waves same as wind direction
X Direction or period of waves indeterminate
M Measured wind

NOTE: The observations are selected from those with winds ≥ 25 kn or waves ≥ 25 ft from May through August (≥ 41 kn or ≥ 33 ft, September through April). In cases where a ship reported more than one observation a day with such values, the one with the highest wind speed was selected.

# Rough Log, North Atlantic Weather

## June and July 1978

ROUGH LOG, JUNE 1978--The storm track pattern was generally displaced northward this month. There was a concentration of storm centers over the Canadian Northwest Territories north of Hudson Bay. The mean climatic storm track that passes over Lake Superior and up the St. Lawrence River Valley was oriented from Lake Winnipeg to James Bay to Kap Farvel. At Kap Farvel the track was joined by a secondary track out of the St. Lawrence River Valley. From Kap Farvel the track moved over the Denmark Strait. A few storms traveled eastward south of Iceland. Early in the month there were several storms over the central ocean between Newfoundland and Portugal.

The mean pressure pattern was dominated by the 1029-mb Azores High near 39°N, 38°W. This was 5 mb higher and about 400 mi north of its climatic position. A 1009-mb Icelandic Low was normally located east of Kap Farvel. A deeper 1007-mb LOW was centered over Committee Bay north of Hudson Bay. The anomalous LOW reflected the many storm centers over the Northwest Territories. The pressure over the eastern United States was 2 to 3 mb higher than normal.

The primary anomaly was a positive 10-mb center near 48°N, 39°W, reflecting the higher pressure and northern displacement of the Azores High. The LOW over northern Canada produced a negative 5-mb center near the LOW center. In general, the pressure over Europe was below normal, but there were only two weak short-lived LOWs over the mainland.

In the upper air at 700 mb the primary LOW center was shifted southward and nearly vertically stacked with a LOW over northern Canada. The surface was 88 m lower than the climatic mean. The trough paralleling the North American East Coast was sharper than usual with a pronounced ridge over the central ocean from 35° to 55°N.

There were the usual number of tropical disturbances, but none developed into more intense tropical circulations.

Extratropical Cyclones--June was a rather quiet month. No severe cyclones either tropical or extratropical affected the seas and larger vessels. On the 4th the DOCTOR LYKES ran into squalls over the Gulf of Mexico south of New Orleans. The 1800 report indicated 68-kn southerly winds.

This was not a single storm, but a series of frontal waves on the front that extended south of the parent LOW that moved eastward from Labrador. The first wave was analyzed near Cape Sable on the 1200 chart of the 4th (fig. 53). A 1030-mb HIGH was drifting southeastward from near 45°N, 35°W. This produced a tight gradient on the eastern side of the front. The HUDSON was near 50°N, 45°W, and was struck by 38-kn winds out of the south at 0000 on the 5th.

By the 1200 analysis of the 5th this frontal wave no longer could be found, but a new one was indicated near 43°N, 55°W. The HUDSON was now near 50°N, 44°W, with heavy rain and 40-kn winds out of the southwest. The KOSMONAUT GAGARIN was near 49°N, 42°W, with 37-kn southerly winds. The seas were running from 8 to 12 ft. This frontal wave was identifiable through the 0000 chart of the 7th.

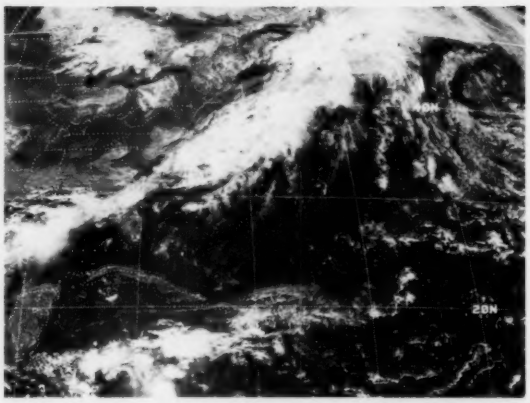



Figure 53.--The shape of the frontal wave can be seen in the cloud pattern east of Cape Sable at 1700.

The first week of the month a LOW had moved eastward across northern Canada. Early on the 7th the center was near Resolution Island. The 0000 chart of the 8th showed this LOW had disappeared, and another had formed about 300 mi to the north off Home Bay of Baffin Island. At 1800 on the 7th, a vessel near 60°N, 50°W, reported 37-kn southerly winds. The 0000 report of the 8th indicated the DANA was very near the center of the storm with 991-mb pressure and 44-kn southeasterly winds. She found seas of 26 ft and temperatures only slightly above freezing.

At 1200 the SISIMUT (67°N, 57°W) and another ship had 37-kn winds from the south with no seas reported. The LOW drifted northwestward, then southward over Baffin Island. It disappeared on the 10th as a LOW moved up the St. Lawrence River Valley.

This front was associated with the LOW described above. On the 9th a frontal wave developed over Maine. The LUCY MAUD MONTGOMERY was in the Gulf of St. Lawrence with 35-kn southerly winds. At 1200 the ALERT near 46°N, 58°W, and another ship had 36- and 40-kn winds, respectively. The LOW was 996 mb at 0000 on the 10th over Anticosti Island. The IXIA (44°N, 54°W) had southwesterly 43-kn winds blowing against her port side. On the 11th the NARWHAL (49°N, 54°W) was contending with 40-kn westerlies. It appeared that the storm would move into the Labrador Sea west of Greenland, but it turned to the northeast and skirted Kap Farvel. The winds were generally below gale strength.

On the 13th the POSEIDON was south of Kap Farvel

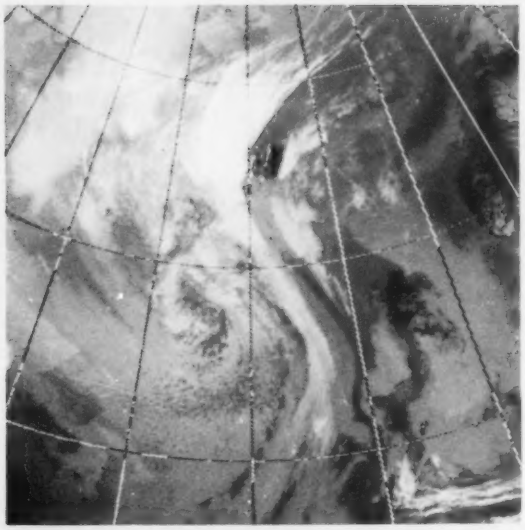


Figure 54. -- The mountains of Iceland can be seen in this DMSP infrared image early on the 14th. The whiter the clouds, the colder and higher their tops.

with 40-kn winds and 16-ft seas. By 1800 the winds had risen to 48 kn and the seas had built to 26 ft. An English ship radioed 45-kn winds and 25-ft waves on the 14th south of Iceland (fig. 54). At 1200 the LOW was 988 mb near 60°N, 25°W. Nearly a dozen ships reported gale-force winds in the vicinity of Iceland that day.

Figure 55.--The large Azores High was 1039 mb near 41°N, 38°W, at about 1700 on the 20th. A front stretches east from Labrador, and a distinct cyclone is over Montreal.

On the 15th OWS Lima measured 35-kn winds with 16-ft swells. Romeo had 20-ft swells, while a ship between the two recorded 21 ft. By the 16th this center had disappeared, and a new one formed over Wales to become one of the few storms to traverse the continent.

The third week of the month the Azores High dominated the Atlantic from 15° to 50°N and coast to coast. It averaged around 1035-mb pressure and was centered in the vicinity of 40° to 45°N and 30° to 35°W (fig. 55). During the fourth week the HIGH broke down

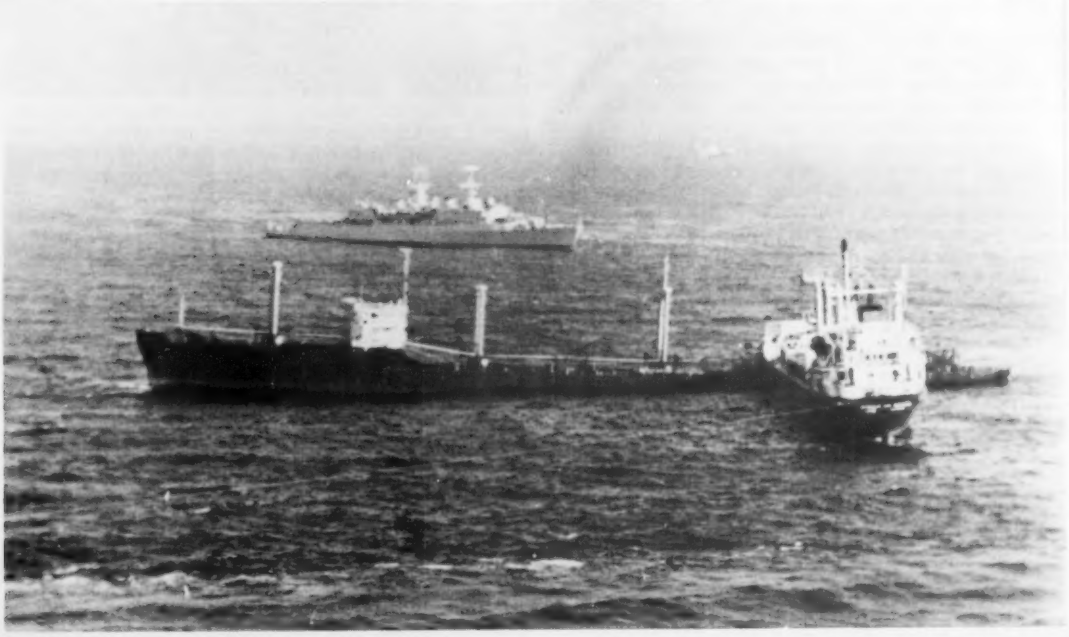


Figure 56.--This low-level view of the IBN BATOUTA (stern) and the YELLOWSTONE shows two rescue ships in the haze and fog in the background. Aerial view appears on the cover. Wide World Photo.

Figure 57.--This closeup shows the damage to the bow of the IBN BATOUTA, which hides even worse damage to the side and engineroom of the YELLOWSTONE. Two seamen died and three were missing. Wide World Photo.

some, but held its own. Fronts were able to penetrate, and two small LOWs were analyzed on the eastern and northeastern edges, but they were not significant. There were isolated reports of gale-force winds, but no systematic storm.

Casualties--The LAGADA BAY (4,530 tons) and the LOBITO PALM (5,923 tons) collided in fog in the Benin River in Nigeria on the 1st. On June 2 it was reported that the WORLD HORIZON (102,326 tons) had gone down by the head with forepeak flooded in heavy swell while southwest of Port Elizabeth. The vessel was loaded and proceeding from the Persian Gulf to Curacao. Divers were unable to inspect the vessel off Mossel Bay owing to weather. An inspection was made at St. Helena Bay, and the bulbous bow and forepeak tank were missing.

The 11,034-ton YELLOWSTONE (figs. 56 and 57) and the 2,839-ton IBN BATOUTA collided in fog on the 12th about 14 mi from Gibraltar. The YELLOWSTONE sank on the 13th, while the IBN BATOUTA proceeded to Cadiz.

The tug IRMA sank during a storm off Pass Christian on the 29th. The fishing vessel CAPTAIN GIBBY sank during a squall at Empire, La.

ROUGH LOG, JULY 1978--The majority of the low-pressure centers occurred over Canada. A mean track would extend from northwest of Lake Winnipeg to south of James Bay to Labrador and then northward toward Baffin Bay. Two storms tracked northeastward off the east coast of the United States to join the path of the few storms that continued eastward out of Canada. This path continued eastward, then turned northeastward south of Iceland, and ended over the Norwegian Sea. During the second week of the month one LOW abruptly turned southward, and during the fourth week another turned northward near the same position south of Iceland. No storms penetrated the European continent south of 55°N. The storms basically followed the climatic pattern, except climatology indicates more storms off the North American east coast and more continuing eastward from Canada.

The mean pressure pattern south of latitude 55°N was very near the climatological normal. The primary feature was the Bermuda-Azores High. At 1026 mb it was normally located near 33°N, 39°W. There was an anomalous subcenter off the coast of Portugal. The usual HIGH over the Greenland icecap slipped southward off Angmagssalik. The LOW usually over Iceland was displaced to near the Faeroe Islands. The primary LOW, which is normally over Cape Chidley, was displaced to the Foxe Channel north of Hudson Bay.

The largest departure from normal was a positive 6 mb associated with the Greenland High. The largest negative anomaly was 3 mb centered with the Foxe

Channel Low.

The upper air differed significantly from climatology over the area north of latitude 55°N. The normal trough that usually extends from the North Pole southward along the eastern North American coast was replaced by a deep closed LOW at 700 mb. It was centered near Repulse Bay of northern Canada. The circulation around this LOW brought a sharp ridge northward over Greenland. A second anomalous LOW was situated over the Norwegian Sea. The High along latitude 30°N over the central ocean was slightly lower than normal.

The LOW and ridge over the northern areas produced large anomaly centers of opposite polarities over northeastern Canada and Greenland.

Tropical storm Amelia developed over the western Gulf of Mexico on the last day of the month.

Extratropical Cyclones--This storm moved out of the northern plains on July 1. It crossed the coastline near Delaware Bay on the 4th, bringing heavy rains to that area (fig. 58). The SISAK was several hund-

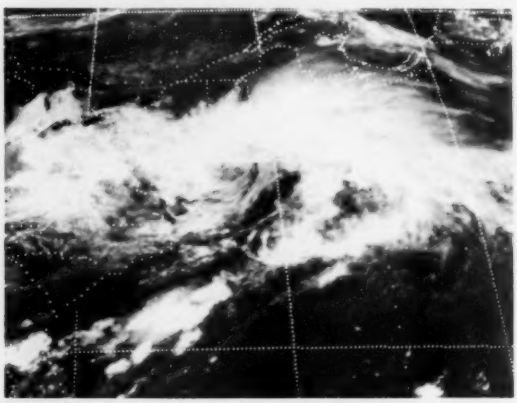


Figure 58.--At noon on Independence Day many picnics were being rained out in the northeastern States as the cyclone moved off the coast.

red miles off Cape Hatteras south of the front and reported 53-kn southwesterly winds. At 1200 on the 5th the 1000-mb LOW was near 40°N, 67°W. At that time the BEN OCEAN LANCER was northeast of the center near 43°N, 62°W, with 45-kn easterly winds. The EXPORT FREEDOM found 40-kn winds from the south and 13-ft waves near 39°N, 51°W. The storm was northeast of St. John's on the 7th, and the PERSEY had northerly 47-kn winds near 50°N, 50°W. At 1800 the German ship DIMC at 49.4°N, 40°W, radioed a report of 52-kn winds out of the southwest driving 33-ft seas (fig. 59). As she sailed on a southwestward course on the 8th, the winds dropped to 40 kn and the seas to 28 ft. Later that day the CITY OF GUILDFORD was east of the 986-mb center with 37-kn winds and swells of 23 ft. OWS Charlie measured 39 kn and 13-ft seas.

On the 10th the LOW abruptly turned southward as a HIGH aloft drifted southward from the Norwegian Sea to southwest of the Faeroe Islands. The LOW, which at this time could not be considered a significant storm, continued a jagged southerly track until the 15th, when it was centered over the Azores. On

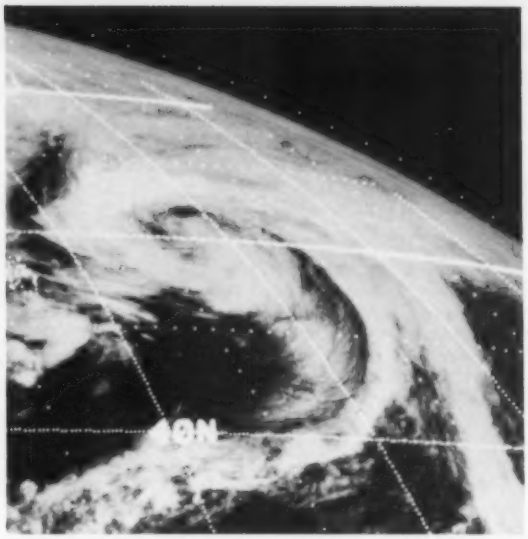



Figure 59.--The storm is centered near 50°N, 43°W, at 1700. High winds and seas are hidden beneath the heavy clouds southeast of the center. Hopefully, these severe conditions will be detected and known when SEASAT becomes operational.

the 14th a ship reported 35-kn winds and 20-ft seas in the western quadrant. After midday on the 15th, the LOW swung northward for 24 hr, then eastward to dissipate over the Bay of Biscay on the 18th. This was an exceptional storm in that it survived as an entity for 18 days.

This LOW was first analyzed on the 0000 chart of the 17th over the entrance to the Chesapeake Bay. On the 18th the 1005-mb LOW was over Newfoundland with a trough extending eastward into the Azores High. The ROMAN PAZINSKI was north of the trough line and 600 mi east of the LOW with 43-kn south-southeasterly winds. The pressure dropped to 994 mb at 1200 on the 20th near 56°N, 36°W. A SHIP reported 41-kn southerly winds about 300 mi southeast of the center at 0600. At 0600 on the 21st the C. P. TRADER was near 54°N, 37°W, with 37-kn northwesterly winds, 13-ft seas, and 23-ft swells 30 degrees off the seas (fig. 60).

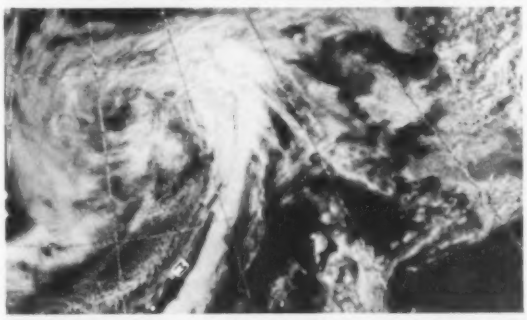


Figure 60.--The satellite caught this view about 1300 on the 21st. The upper-air center is near 57°N, 28°W. Seven hours earlier the C. P. TRADER was in the area of the heavy clouds south of the center.

On the 22d the 988-mb LOW was south of Iceland at latitude 58°N. The ANNA JOHANNE was at latitude 60°N with 44-kn northeasterly winds and 21-ft seas. At 1200 OWS Romeo measured 35-kn gales and 20-ft seas. Near the storm's center four ships reported winds of 45 kn from the northeast with the highest seas being 21 ft. Ocean Weather Station Lima measured 40-kn winds on the 23d after the storm passed almost directly over her position. At this time the LOW turned northward and moved into the Norwegian Sea where it died on the 26th.

This frontal wave developed over the Midwest and raced eastward over the Great Lakes to the Maritime Provinces of Canada on the 24th. It was associated with a fast-moving short wave in the upper air. At 1200 on the 25th the surface LOW was 998 mb near 47°N, 42°W. The HANS SACHS (43°N, 49°W) had 35-kn winds on her starboard bow. By the 26th an upper air LOW had developed, and the storm slowed in its race eastward. Six ships in the southern half of the circulation reported 35- to 40-kn winds with the highest seas and swells reported at 16 ft. On the 27th the LOW was absorbed by another over Iceland.

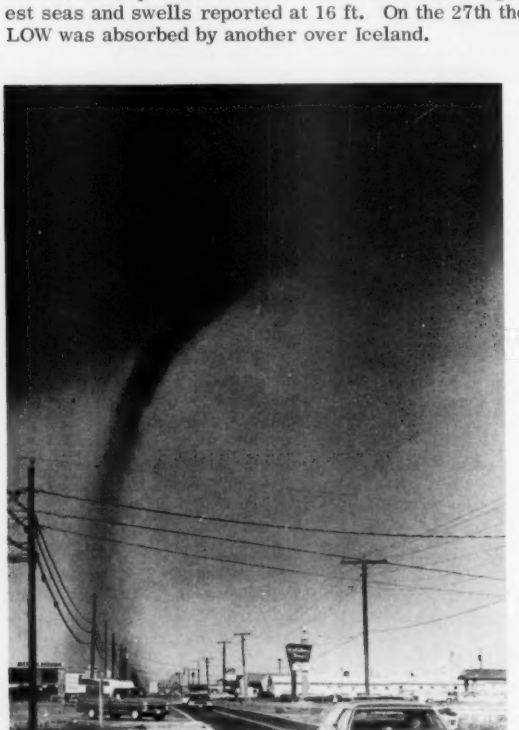


Figure 61.--This waterspout struck Kill Devil Hills, N.C., on the last day of July. Wide World Photo.

On July 31 an east-west-oriented front extended across the Norfolk, Va., area. Weak frontal waves were moving along the front triggering thunderstorms, especially south of the front. A waterspout (fig. 61) developed with one of these severe thunderstorms and struck Kill Devil Hills on the North Carolina Capes. One person was known dead, and several others were missing as a result.

Tropical Cyclones--Up until the end of July it had been a typical Texas summer--hot and dry. High temperatures and lack of moisture were causing cotten balls to open, pecan nutlets to drop, and peaches to ripen slowly. Range and pasture lands were deteriorating, range fires were a problem, and stock water supplies were drying up. Then along came Amelia--and all of a sudden Texas had too much water.

Amelia popped up close to the Mexican coast about 30 mi south of Brownsville, Tex., early on the 30th (fig. 62). She moved north-northwestward and intensified. Maximum winds reached 45 kn before Amelia crossed the coast just north of Brownsville during the night of the 30th. These winds were enough to cause tides 2 to 4 ft above normal and to cause some damage to shipping. At least five shrimpboats were missing, and the 34-ft pleasure boat MISS LAURIE ANN was wrecked. But Amelia's real threat were her rains.

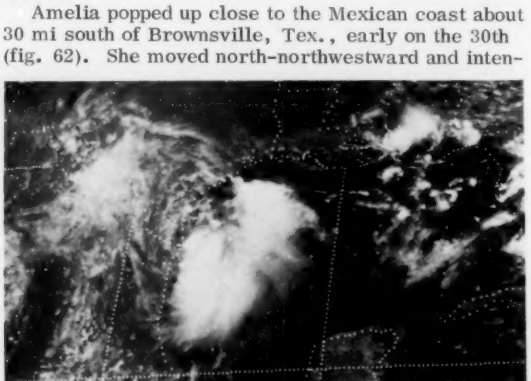


Figure 62.--Tropical storm Amelia off Brownsville, Tex., at 1700 on the 30th.

It began slowly at first--the normal showers and thunderstorms expected with a weakening tropical storm as she moves overland. By the 1st several places had recorded more than 5 in and a few more than 6 in. Flash flood warnings were up for southern Texas. The next night thunderstorms dumped heavy rains at the head of the Guadalupe, Medina, and Sabinal Rivers. Vanderpool reported 11 in, and there were amatuer radio reports of up to 20 in over the hill country northwest of San Antonio. The ill-defined remains of Amelia continued to move slowly northward. And the rains spread westward and northward. The resultant flooding was widespread and devastating. Record rises along the Guadalupe include a 1-ft rise in 20 min at Kerrville, where 22 in of rain had fallen. The river rose several inches above the bridge of Highway 281--the bridge is 59 ft high. Sev-

eral other rivers and streams reached record crests, and by late on the 2d rains had spread to Roswell, N. M. By Friday the 4th 9 to 11 in of rain had fallen over northern central Texas. In the Abilene area 18 in were recorded at Stamford and 14 in at Albany. Record flood stages occurred on the Brazos River at Ft. Griffin, where reports of up to 30 in of rainfall were received.

Casualties--The fishing vessel CAPTAIN GIBBY that sank during a squall at Empire, La., on June 30 was raised on July 2 and sent to the repair yard. The 10,506-ton PHOTINIA, which went aground in Lake Michigan owing to high winds and waves during May, was refloated on July 7 with the assistance of 7 tugs. The dredging barge PENNSYLVANIA foundered in rough seas in Rockaway Inlet while under tow on the 31st. Swells of 3 to 5 ft hindered the containment and control of No. 2 and No. 6 oil, which was leaking from the barge.

# Rough Log, North Pacific Weather

## June and July 1978

ROUGH LOG, JUNE 1978--Storms over this ocean were few and shifted to the west. Climatology shows the primary storm path is from Kyushu east-northeastward to the central ocean and then into the Gulf of Alaska. At midocean a branch turns northward into the Bering Sea. This month the primary track was from an area about 400 mi east of Honshu northeastward into the Bering Sea. A secondary track left the same area, but tracked eastward then turned northeastward to the Alaska Peninsula. Early in the month one LOW tracked from south of Kyushu to Vancouver Island, taking 12 days.

The Pacific High was, by far, the most dominant feature on the mean sea-level pressure chart. The 1030-mb center at 40°N, 155°W, was 6 mb higher than the climatological center and about 600 mi northwest of its climatic position. A ridge extended northward to the southern coast of Alaska. The 1010-mb climatic Aleutian Low, which is normally north of Adak Island, did not exist. Rather, there were four small LOW centers surrounding the Sea of Okhotsk. The lowest was 1003 mb over Siberia northwest of the Sea of Okhotsk.

The differences in pressure and location of the surface centers resulted in two major large anomaly centers. The largest, and probably the most significant as far as the mariner was concerned, was a positive 11 mb near 45°N, 158°W. In general, this positive anomaly area covered the major portion of the ocean from 20°N to Alaska and coast to coast east-west. The exception to this was an area of negative values with a minus 8-mb center over the Kamchatka Peninsula. This area included most of the Bering Sea, the Sea of Okhotsk, and Hokkaido.

The upper air pattern had a closer resemblance to climatology. At 700 mb the High was centered northwest of Hawaii about 800 mi west of its usual position and 10 m higher. The Low was shifted northwestward over the Siberian coast, rather than north of Adak Island as per climatology. The height was about 47 m lower than the climatological mean. There were the usual troughs paralleling the coastlines with a ridge over Alaska.

There were six tropical cyclones, three on each side of the dateline. In the eastern Pacific there were tropical storm Bud and hurricanes Carlotta and Daniel. The western Pacific experienced tropical storms Polly, Rose, and Shirley.

Extratropical Cyclones--Monster of the Month--The East China Sea spawned this storm on the 2d. It was an especially long-lived storm for this time of year, lasting until it reached Vancouver Island on the 14th. The storm passed south of Japan on the 3d and 4th bringing heavy rains to the Islands. On the 5th the 984-mb LOW was near 45°N, 152°E. There were many reports of gales. The JUNEAU MARU found 45-kn winds and 16-ft seas east of the center near 44°N, 156°E. Several other ships also had 16-ft waves near the front.

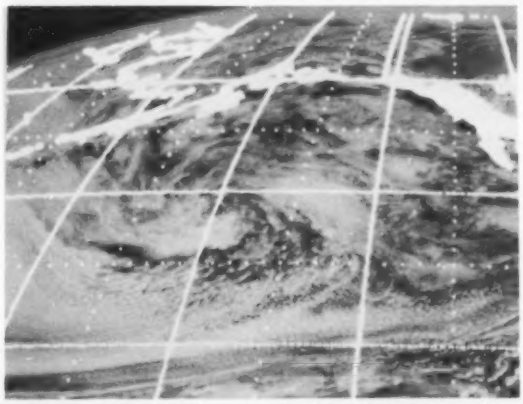


Figure 63.--The storm is near 50°N, 150°W, at 2045 on June 10. The PRESIDENT VAN BUREN was about 600 mi to the southeast, where the cloud pattern indicates a divergent area in the wind field.

On the 6th the YOZAN MARU (44°N, 154°E) was sailing into 44-kn westerly winds with 21-ft waves. At 1200 the 976-mb storm was near 50°N, 160°E. The NORDKAP and SHIN SHIEN both had 45-kn winds south of the center with waves up to 20 ft. Gale-force winds continued into the 7th, when the storm entered the Bering Sea.

As it crossed the colder waters of the Bering Sea, it weakened; but the westerly winds from its circulation extended south of latitude 45°N. On the 10th the PRESIDENT VAN BUREN was in the warm sector of the frontal system (42°N, 139°W) and reported 50-kn southwesterly winds (fig. 63). The storm was now tracking southeastward across the Gulf of Alaska. By the 12th it was idling off the coast of British Columbia. A ship beneath the upper air trough was hit by 45-kn northwesterlies. At this time the LOW was only 1008 mb. On the 14th the storm was headed toward the Strait of Juan de Fuca and rapidly dissipating.

This storm was the second of two that reached the North American coast, excluding Alaska. This one developed as a wave on a weak front that had penetrated the Pacific High. It was first found on the 3d about midway between Hawaii and Seattle. Late that day the FEDSTEEL was near 40°N, 153°W, northwest of the LOW. Her winds were 43 kn and seas 13 ft. Twelve hours later as she moved westward and the storm moved northward, the winds were 48 kn. At 0000 on the 5th the 1000-mb storm was near 40°N, 143°W. The TRANSCHAMPLAIN had just penetrated the front with 35-kn winds. A ship northwest of the center had 40-kn gales. Later on the 5th the VIOLET northwest of the center reported 36-kn gales. The storm continued to move northward until the 8th, when it suddenly turned southeastward and the high-pressure cell off the California coast gave way to its continued pressure. On the 9th the center crossed Vancouver Island and disintegrated.

As a LOW and associated front moved over the Asian coast on the 11th, the LOW stalled and the front broke away and continued to move. At 1200 another LOW had formed at the occlusion north of Hokkaido. Heavy rains fell on Kyushu flooding 600 homes and roads and railways. Up to 11 in of rain fell in 24 hr (fig. 64).

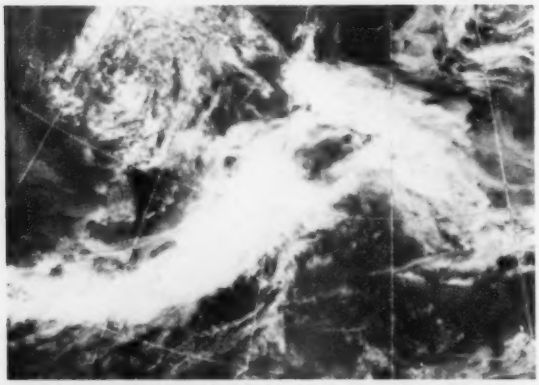


Figure 64.--The new LOW is not readily apparent in the high cloud field early on the 11th. The heavy clouds over Japan drenched the area. The old LOW can be seen over Korea.

The FEDSTEEL was south of the front (37°N, 147°E) on the 12th with 43-kn winds from the south-southwest. The 998-mb LOW was racing eastward under upper air zonal flow. On the 13th it caught up with a LOW centered over the Bering Sea and moved south of it. On the 14th the JAPAN ACE (42°N, 175°W) and a SHIP (46°N, 171°W) both had 40-kn winds from 200° just east of the cold front. At this time the LOW turned sharply northward and absorbed the circulation of the LOW over the Bering Sea. By the 15th the storm had crossed the Alaska Peninsula and was over western Alaska. The pressure gradient appeared like it would have supported gale-force winds, but none were reported. The storm entered the Bering Strait on the 16th and died.

This LOW appeared in the vicinity of the Near Islands on the 15th. It moved northward prior to turning eastward late on the 16th. The VAN WARRIOR was sailing northeastward near 49°N, 170°W, with 35-kn southerly winds. A SHIP in the East Siberian Sea found 40-kn easterly winds off Mys. Shelagskiy. The JAPAN RAINBOW found 50-kn winds out of the west-southwest on the 17th near 54°N, 164°W. Several ships found 35- to 40-kn gales with one measuring seas of 20 ft. On the 18th the LOW was headed northward through the Bering Strait.

The Pacific High gradually had built to 1038 mb by the 14th. The pressure gradient along the U.S. West Coast was increasing as were the northerly winds. At this time the heat LOW over the Great Basin was weak. By the 18th the central pressure had built to 1042 mb near 45°N, 145°W. Two SHIPs reported 35 kn off Seattle. On the 19th (fig. 65) the PORTLAND found 45-kn winds, and the S. P. LEE had 38-kn winds and 20-ft waves off Vancouver Island. Farther south the TOYOTA MARU out of San Francisco radioed 62-kn winds. On the 20th the ORIENTAL SOVERIGN and PACSTAR found winds in the 40-kn range off Seattle. The HIGH was slipping slowly westward, and without a strong heat LOW the winds did not develop as they do at times with a weaker HIGH. On the 23d the YING YUNG was on the Great Circle track out of Seattle and headed into 21-ft swells. That day the pressure dropped below 1040 mb, and the center drifted slightly westward, easing the gradient along the coast.

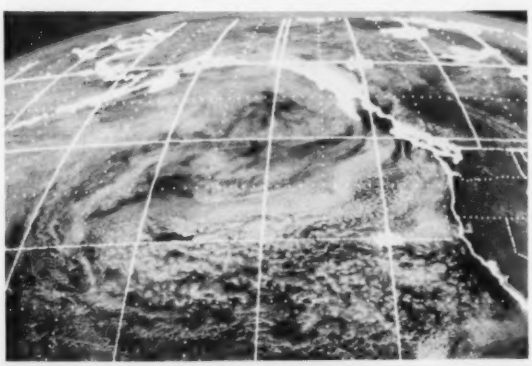


Figure 65.--High pressure is normally a sign of good weather, but in this case the area has many clouds with high winds on the eastern side along the coast.

Weak LOWs had been running up the west side of the Pacific High but had not made much headway against it. On the 21st a LOW was found east of Hokkaido. On the 23d it was 996 mb near 45°N, 172°E. Only near gales were being reported. On the 26th the storm was over Kodiak Island. A SHIP near 52°N, 137°W, had 45-kn winds. Later in the day another LOW developed over interior Alaska and then dissipated into only a trough. The last days of the month the Pacific High again became the major influence and dominated the eastern two-thirds of the ocean.

Tropical Cyclones, Eastern Pacific--Tropical storm Bud and hurricane Carlotta both began on the 17th. Bud developed about 550 mi west of Clipperton Island, while Carlotta formed about 230 mi to the northeast of the Island. Both moved on a general west-northwesterly track. Carlotta reached hurricane strength on the 19th just before crossing the 115th meridian, while Bud became a tropical storm on the 17th and hit a peak intensity of 55 kn on the 19th after crossing the 125th meridian (fig. 66). Bud degenerated rapidly

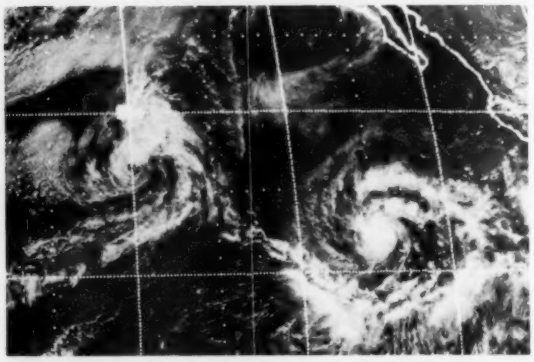


Figure 66.--Bud (left) is being chased by Carlotta (right) across the eastern ocean on the 19th.

after that and was a weak depression by the 20th. Carlotta, however, had just begun. Maximum winds near her center rose to 105 kn on the 20th and to 115 kn by the 21st. At this time she was spotted approaching the 120th meridian near 14°N. Winds remained above 100 kn for another day, but then Carlotta began to cool. She fell below hurricane strength on the 24th just past 125°W. By the 25th Carlotta was a depression.

Daniel appeared on the 26th near 13°N, 100°W. He moved west-northwestward until reaching 107°W on the 28th, and then he headed westward for the next 5 days. This journey covered a distance of some 2,000 mi. Daniel achieved hurricane strength on the 29th as he cruised 120 mi to the south of Socorro and the Clarion Island. As he passed south of Clarion, winds near his center hit 100 kn (fig. 67). Daniel maintained this intensity for 2 days, but on July 2 he began to weaken. The following day he fell to depression strength after crossing 135°W near 17°N.

Tropical Cyclones, Western Pacific--Tropical-cyclone activity was nill during the first half of June. In the second half of the month three weak, short-lived tropical storms--Polly, Rose, and Shirley--developed in

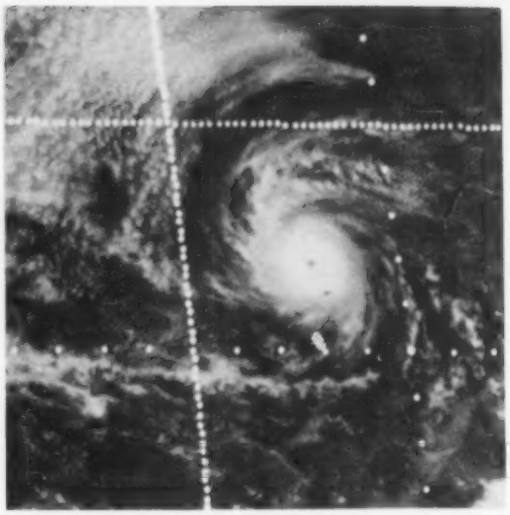


Figure 67.--Daniel has a very distinct circular eye in this SMS image on the 30th.

the Philippine Sea-South China Sea region. On the 17th Polly formed about 150 mi southeast of Okinawa. She moved northwestward through the Ryukyu Islands and attained tropical-storm strength the following day. Maximum winds reached 50 kn on the 19th (fig. 68). However, Polly was recurving by this time and was prevented from further intensification when she ran afoul of Kyushu on the 20th. The rugged island caused her to weaken rapidly.

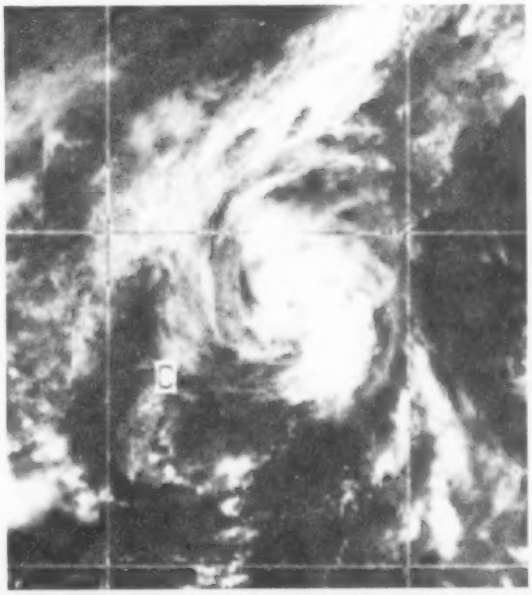


Figure 68.--Tropical storm Polly is near maximum strength of 50 kn in the vicinity of Okinawa.

Rose encountered a similar problem with Taiwan on the 24th. She had come to life about 120 mi east of northern Luzon on the 23d. Winds climbed to 40 kn late in the day, but before she could really get up a head of steam, Rose slammed into Taiwan and died. Shirley's fate was almost predetermined when she blossomed just 120 mi east of Vietnam on the last day of the month. She managed to generate 45-kn winds before running aground near Qui-nhon before the day was out.

Casualties--The tuna fishing boat YURYO MARU (99 tons) and the Taiwanese freighter CHEN CHANG (4,995 tons) collided in fog off Iwate Prefecture on the 21st. The YURYO MARU capsized and only 2 of the 16 crewmen were rescued. Two ferries collided off Awaji Island in the Inland Sea on the 26th in dense fog. They were the 1,758-ton HAYABUSA No. 2 and the 1,608-ton HAYABUSA No. 5. Five persons were injured.

ROUGH LOG, JULY 1978--The cyclone track pattern was shifted westward from the climatic location. The concentration of cyclones that normally form in the vicinity of Japan was located over the continent over Mongolia and Manchuria. These generally remained over the land area, rather than tracking into the Bering Sea as the climatic pattern indicates. The storms that had their genesis over the marine area were spread out without a concentrated path, except that the majority terminated over the eastern Bering Sea and Alaska Peninsula. No significant low-pressure center penetrated the coastline east of 150°W.

The mean sea-level pressure chart for the month was dominated by the Pacific High. Its 1029-mb center was near 40°N, 145°W. This was 4 mb greater and 5° longitude east of its climatological position. Its influence also extended farther north and west than usual, including the Sea of Japan. A trough with a 1010-mb LOW near 54°N, 172°W, extended southeastward out of Siberia. The deepest LOW was 1002 mb and centered over the western shore of the Sea of Okhotsk.

There were five major anomaly centers that influenced the weather and its location or vice versa. The Pacific High produced two plus 4-mb centers--one over the eastern ocean near 44°N, 140°W, and the other near 43°N, 165°E. There were three negative centers: a minus 5 mb over the Aleutians near 170°W, a minus 6 mb collocated with the LOW on the western shore of the Sea of Okhotsk, and a minus 4 mb south of Japan near 25°N, 140°E.

The zonal flow at 700 mb was concentrated between latitudes 40° and 55°N. The High was near normal, but its influence extended farther west and north than usual. There was a low center over the Bering Sea, rather than a trough. This increased the sharpness of the ridge that normally exists over the northern North American west coast. The upper air anomaly centers closely matched those at the surface.

There were eight tropical cyclones, four over each ocean. There were typhoons Trix, Virginia, and Wendy and tropical storm Agnes over the western North Pacific. Tropical storm Emilia led off in the eastern North Pacific, followed by hurricanes Fico, Gilma, and Hector.

Extratropical Cyclones--Monster of the Month--The first storm of the month raced northeastward from between two HIGHs on the first day of the month. It was north of the Aleutians over the Bering Sea near 55°N, 175°W, by the first chart of the 2d (fig. 69). At that time the VAN ENTERPRISE was south of the islands near 51°N, 178°W, with 47-kn winds out of the west-southwest. The swell report indicated 41 ft.

By the 0000 chart of the 3d, the storm had absorbed four other small LOWs that were over the western Ber-

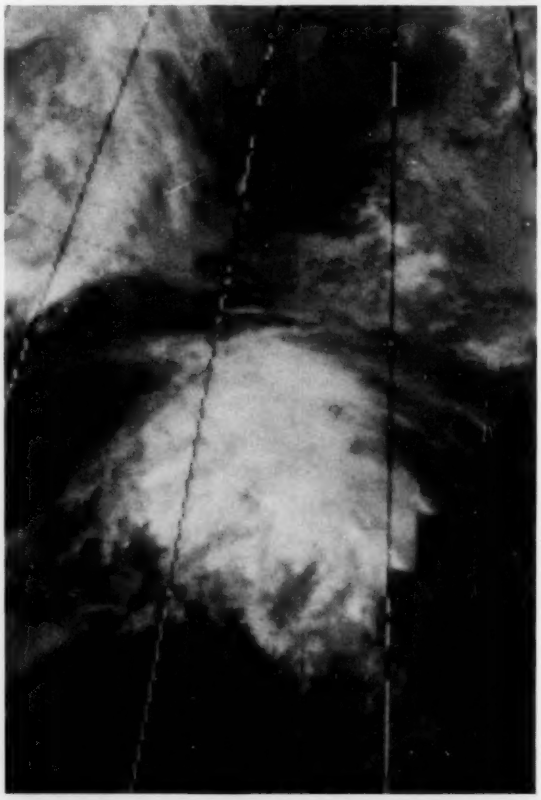


Figure 69.--This polar mozaic of DMSP infrared images does not indicate a very strong or well-organized storm.

ing Sea and the Gulf of Alaska. There were many gale reports around the storm. The VAN ENTERPRISE now had 60-kn westerly winds, and the waves had dropped to 16 ft. The MARITIME BRILLIANCE (52°N, 139°W) was slapped by 54-kn southerly winds and 20-ft waves east of the storm and its fronts, while the MOBILE ARCTIC (55°N, 145°W) contended with 45-kn easterly winds and 30-ft waves. The report from a Japanese-registered ship near the occlusion indicated swells of 43 ft near 54°N, 151°W. Late on the 3d the storm was crossing the Alaska Peninsula with the pressure rising from its minimum of 982 mb.

On the 4th, 5th, and 6th the storm's center traced a counterclockwise loop just south of Kodiak Island. The maximum winds were in the gale range. By the 7th the LOW had yielded to high pressure.

A frontal wave developed at the point of occlusion of a front that extended southward out of a LOW over Siberia on the 6th. At 1200 on the 7th the 990-mb LOW was near 55°N, 177°W. The MARITIME BRILLIANCE was south of this storm at 53.5°N with 52-kn winds and 18-ft waves. The DALNIY VOSTOK (45°N, 166°W) had 50-kn winds. On the 8th this was a fairly large storm for a summer month (fig. 70). The GRECIAN SPIRIT was at 43°N, 174°W, with 35-kn gales. This was about 750 mi south of the center. The MARITIME BRILLIANCE was still sailing west south of the Aleutians into 45-kn gales. The storm was tracking eastward, but late in the day it swung northwestward over the Pribilof Islands to disappear over the Bering Sea on the 10th. The USCGC MELLON was near 59°N, 178°W, during this time with rain, drizzle, and fog.

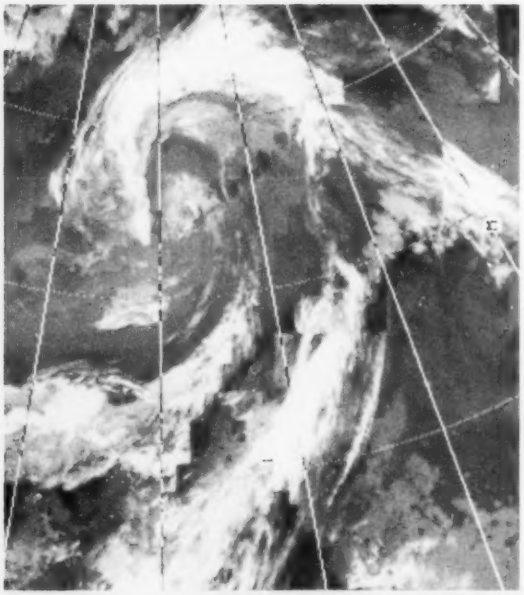


Figure 70.--The large storm is centered near 56°N, 168°W, on the 9th. A large cloud shield is associated with the occlusion to the north. The main front extends south near 150°W. A frontal wave is developing near 43°N, 177°W.

During the first third of the month the Pacific High was firmly entrenched in the vicinity of 40°N, 140°W (fig. 71). The pressure gradient between the heat LOWs over the western desert area of the United States and the HIGH resulted in many northerly gale reports along the U.S. West Coast. The highest appeared to be 45 kn off Portland, Oreg.

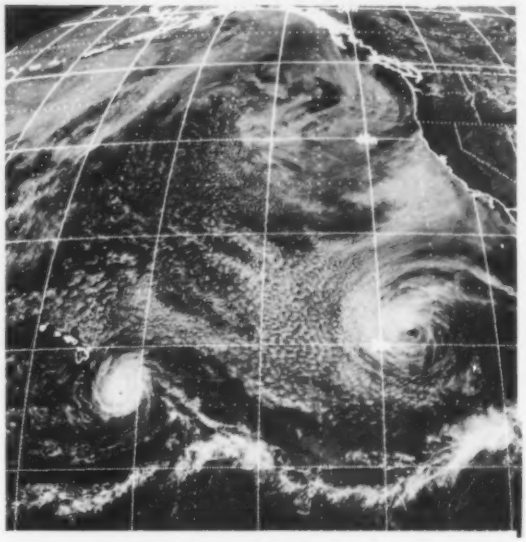


Figure 71.--Late on the 19th the HIGH was centered near 46°N, 141°W. Stratus and fog lie off most of the North American coast. Hurricanes Fico and Gilma are moving across the southern ocean.

This frontal wave was a little different in that it originated on a warm front on the 25th. Most waves are found on the more unstable cold fronts. The LOW itself was not especially significant, except for the cold front it supported. The significant weather was confined to the area east of the front between the front and a stubborn HIGH centered in the area of 40°N, 160°W.

The LOW moved northeastward and at 0000 on the 26th was 1002 mb near 50°N, 163°E. At that time a SHIP was about midway between the two centers near 49°N, 179°W, and reported 58-kn winds out of the south. On the 27th the OSTROV CHOKALSKOVO was near 44°N, 177°E, with 28-ft swells. The winds in this area had been blowing from a southerly direction for several days as the HIGH drifted toward the south-southeast. Later in the day the analysis showed the HIGH had jumped southeastward; the LOW disappeared, but the front remained.

This LOW formed first in the upper air. The 700-mb chart for 0000 on the 27th had two weak LOWs--one off Vancouver Island and another over the Gulf of Alaska. By the 0000 chart of the 28th they had combined into one center near 56°N, 143°W. The 1800 surface chart of the 27th indicated a surface LOW near 49°N, 156°W. Both the surface and upper air LOWs deepened very rapidly. The VAN ENTERPRISE (50°N, 155°W) was

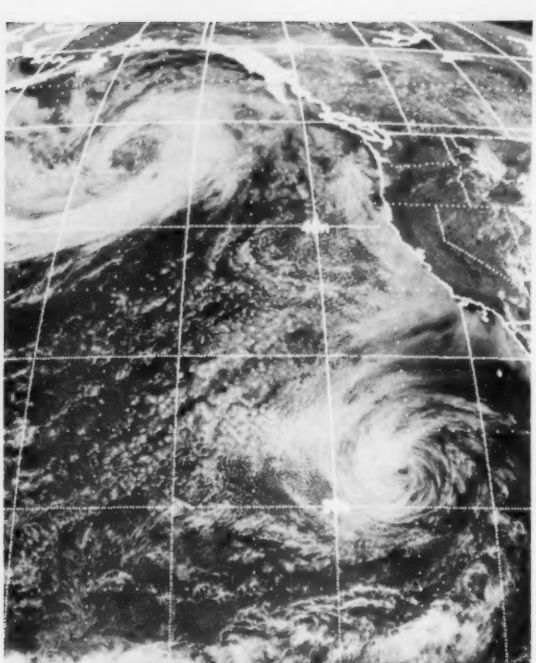


Figure 72.--The extratropical storm was near 47°N, 145°W, at 2045 on the 28th. Compare its appearance with tropical hurricane Hector west of Cape Falso.

less than 1° latitude from the center and was surprised by 62-kn easterly winds. The seas were 15 ft. She was sailing eastward, the same direction the storm was moving, and continued to have winds of about 60 kn, shifting to the north, until the 29th (fig. 72). On the 29th the NEW ENGLAND HUNTER was in the area of 45°N, 150°W, with 40-kn northwesterly winds and 13-ft waves. At 0600 the ARCO PRUDHOE BAY (51°N, 136°W) was headed into 40-kn southeasterly winds. On the 29th the storm started a counterclockwise loop under the upper air LOW, which was centered near 50°N, 145°W, and deepening. The surface LOW was 992 mb at 1200 with OWS Papa in the center.

The winds around the storm were now mainly in the breeze category. The next report of gale-force winds did not come until August 2, when the LEO near OWS Papa reported 40-kn westerlies. The LOW completed the circle and drifted toward the north. Both the surface and upper air LOWs were filling. The surface LOW disappeared from the analysis on the 5th, and the upper air LOW was gone on the 6th.

Tropical Cyclones, Eastern Pacific--Tropical storm Emilia survived less than 1 week. Beginning on the 6th near 15°N, 112°W, she moved west-northwestward for 5 days and dissipated near 22°N, 128°W. During this period winds near her center reached 50 kn during the 8th and 9th. While Emilia was weakening on the 9th, a new storm was brewing about 1,000 mi to the southeast. Fico came to life on the 9th near 10°N, 105°W. Unlike Emilia, he had a long life which took him on a journey south of the Hawaiian Ialands and nearly across the dateline. In addition to being a long-lived storm--Fico lasted until the 28th--he was a powerful storm. On the 11th Fico reached hurricane intensity as he approached the 15th parallel. Winds near his center quickly intensified to 115 kn. Winds remained at about 100 kn or more for the next week as Fico headed westward. The size and intensity of Fico was attested to by the RACHEL which, although some 300 mi northeast of his center, battled giant 40-ft swells in 40- to 50-kn winds that were whipping 30-ft seas. Fico weakened briefly, but on the 20th as he neared the Hawaiian Islands, he regained his potency. Fico remained about 180 mi south of the Islands as he swung toward the west-northwest. Maximum winds remained at 100 kn, and the Islands were pounded by heavy swell. By the 26th Fico showed signs of weakening as he crossed the 25th parallel near 175°W. For a while it looked like he might be the first storm to make it all the way from the eastern North Pacific across the dateline. However, he recurved northward and missed the dateline by a few hundred miles (fig. 71).

While Fico was traveling across the Pacific, two other tropical cyclones had come to life. Gilma formed on the 13th not more than 300 mi east of Fico's spawning ground. On the 22d Hector formed just 60 mi north of where Gilma developed. Both storms became hurricanes and traveled parallel paths. Gilma reached hurricane strength on the 15th near 15°N, 110°W, while Hector did the same on the 23d near 15°N, 105°W. Gilma peaked at about 90 kn from the 16th through the 18th. Hector's maximum winds topped out at about 110 kn on the 26th (fig. 72). Gilma weakened to a depression on the 19th near 21°N, 127°W. Ten days later Hector was a depression about 60 mi to the northeast of this spot.

Tropical Cyclones, Western Pacific--Typhoon Trix popped up just east of the Volcano Islands on the 13th. After moving westward for a couple of days, she turned a counterclockwise loop on the 15th and 16th. By this time Trix was at typhoon strength. The HAMPTON MARU, within 60 mi of the center battled 20-ft waves. Trix remained at minimal typhoon strength for about 2 days (fig. 73). On the 19th as a tropical storm, she

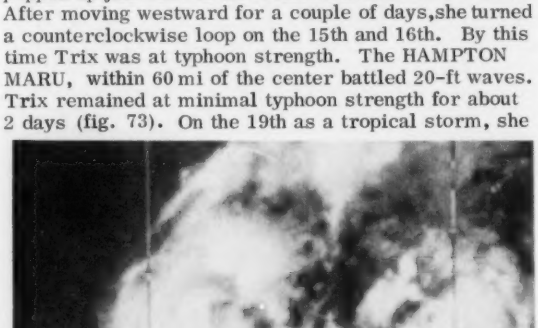


Figure 73.--The circulation of typhoon Trix is not nearly as well organized as the three eastern ocean hurricanes. DMSP Imagery.

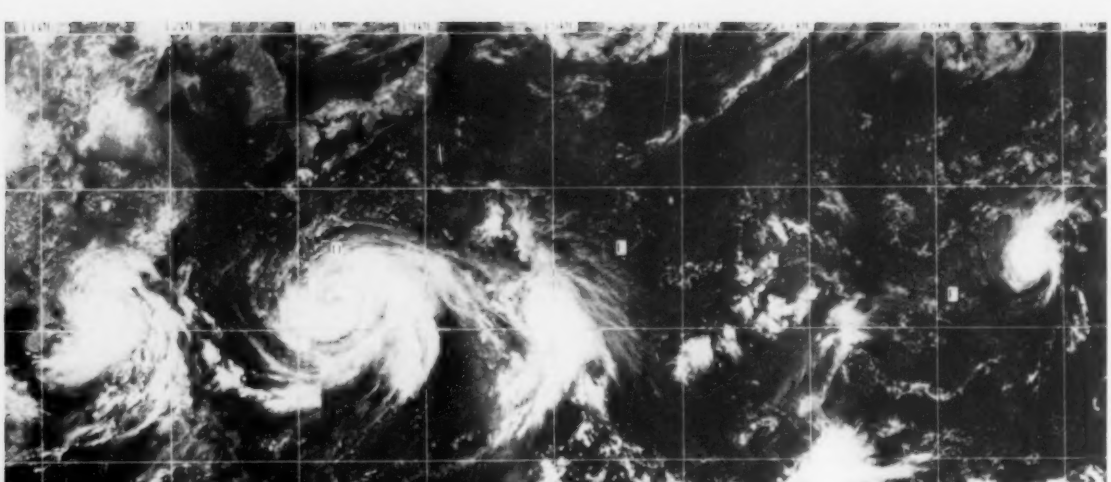


Figure 74.--Four tropical cyclones are portrayed on this satellite composite. Left to right they are Agnes, Wendy, Virginia, and Fico. DMSP Imagery.

Figure 75.--This U.S. Coast Guard photograph of the STAR K. shows the extensive damage to its bow. Fog can be more of a villian than heavy seas when two ships meet in the night.

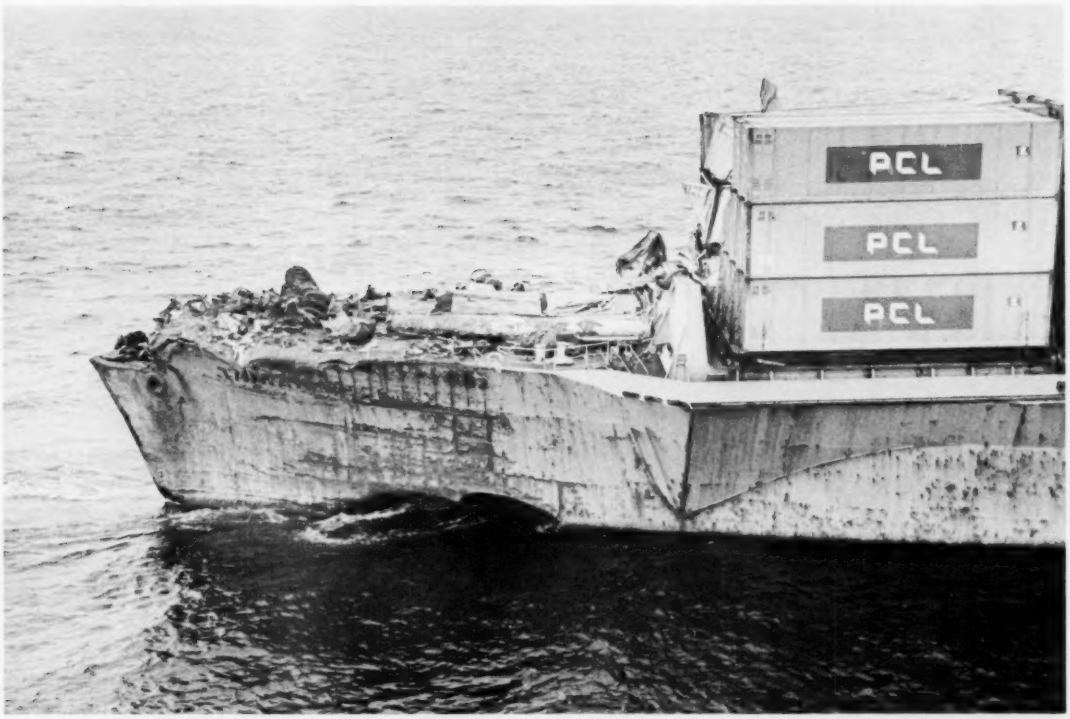



Figure 76.--The TAIWAN PHOENIX was lucky that it did not have to rise anew from the ashes (water) after this collision. U.S. Coast Guard Photo.

turned toward the west-northwest. At the 30th parallel she headed westward. By the 22d after moving through the northern Ryukyus, Trix weakened to a depression.

Typhoons Virginia, Wendy, and Agnes all formed during the 23d and 24th (fig. 74). Virginia and Wendy delivered a one-two punch to Japan at the end of the month, while Agnes belted Hong Kong on the 26th. Agnes formed just 200 mi south of Hong Kong and developed rapidly. Although she was considered a tropical storm, it is more likely that she reached typhoon strength. On the 26th the AMERICAN APOLLO, close to her center, ran into 60-kn winds in 25-ft seas. Around the colony winds of 60 to 90 kn were reported, as trees were uprooted and scaffoldings blown down. Agnes turned a counterclockwise loop and moved close to Hong Kong again on the 29th, as she headed for the China mainland.

Meanwhile, both Virginia and Wendy had reached typhoon strength and were tracking northwestward. Several Japanese ships, including the KUNIMISAN, NICHIJU, and HAMPTON MARU, battled 40- to 55-kn winds in 20-ft seas along Wendy's path. Wendy had come to life in the northern Philippine Sea and passed through the Ryukyus on the 28th. Maximum winds reached 75 kn near her center.

Virginia's winds ranged from 65 to 70 kn as she approached Tokyo on the 31st. For several days prior to this the VOLNA, JUJO MARU, and ARIAKE 1 battled 30- to 50-kn winds in 20-ft swells generated by Virginia. Virginia brushed Honshu on August 1 as she recurved toward the east-northeast. The following day she was weakening rapidly. This same day saw Wendy, now a tropical storm, recurve northeastward and move over Kyushu. There was little damage from either storm, but the warm flow triggered by Wendy combined with a foehn wind and touched off a heat wave across western Honshu. Temperatures were driven into the upper 90's (°F) and even to 100°F in some places.

Casualties--Fog was the culprit this month. On the 3d the 998-ton CHIYO MARU No. 11 and the newly built 19,364-ton Greek OINOUSSIAN VIRTUE collided in fog off Shodoshima. The CHIYO MARU was heavily damaged. The Canadian supply vessel ARCTIC PELLY reported at Tuktoyaktuk (Beaufort Sea in the Mackenzie River Delta) with freezing damage.

The two Korean vessels TOSONG and FLOWER collided in dense fog near 35.1°N, 129.3°E. The 13,255-ton Greek-registered STAR K. (fig. 75) and the 15,024-ton Singapore-registered TAIWAN PHOENIX (fig. 76) collided 600 mi south of Kodiak on the 19th, apparently in fog. The USCGC JARVIS was in the vicinity and standing by. Both ships were towed to the West Coast, the STAR K. stern first.

The American tanker GAINES MILL, which capsized off Kaohsiung in typhoon Thelma (July 25, 1977) while being towed to be scrapped, was refloated on July 22, 1978, almost a year later.

# Marine Weather Diary

## NORTH ATLANTIC, OCTOBER

WEATHER. Storms in the middle and higher latitudes increase in frequency and energy during October. The westerlies have pushed southward, and the 1002-mb Icelandic Low, centered about midway between Iceland and southern Greenland, is deeper and larger than it was in September. The Azores High, centered near 34°N, 35°W, is only slightly weaker (at 1020 mb) than in the preceding month, but it has diminished in size.

WINDS. North of 40°N, the prevailing winds are westerly and generally of force 4 to 6 north of 50°N, and force 3 to 5 between 40° and 50°N. The exceptions are: southerly over the Norwegian Sea, southwesterly over the North Sea, Baltic Sea, and adjacent waters, variable near the Icelandic Low, and light (force-2) northwesterlies through north- to southeasterlies around the Davis Strait. South of 40°N, northeasterly winds prevail of force 3 to 4. Southeasterly force-3 winds blow near the Equator between South America and Africa. Northwesterly winds of force 2 to 3 are prevalent over the Mediterranean Sea.

GALES. Both the frequency of and the area subject to gales increase markedly over the previous few months. Winds of force 8 or more can be expected oceanwide north of about 40°N, with a frequency from 5 to over 20 percent. The highest frequencies occur over a small area south of Greenland's southern tip, the Greenland Sea, and the northern portion of the Norwegian Sea. An analysis of eight Ocean Station Vessels north of 40°N indicates that gales generally last less than 1 day over these waters.

EXTRATROPICAL CYCLONES. The temperature contrast off the Atlantic coast, from Labrador through the Carolinas, is conducive to cyclogenesis. Other principal areas of cyclogenesis lie over midocean within an egg-shaped area oriented in a northeast-southwest fashion and comprising a 250- to 300-mi-wide area between 56°N, 23°W, and 48°N, 37°W; over the Bay of Biscay; within the coastal area from Marseilles east-southeastward to Naples; over all but the extreme southern part of the Adriatic Sea; over the Skagerrak, the Kattegat, and the Baltic Sea to about 61°N; off the northern Norwegian coast; east of Iceland; and off the Denmark Strait coast of Greenland. There are more extratropical cyclones than in September, but primary storm tracks are similar, although most are displaced a little farther south. The secondary cyclone track over the northwestern Mediterranean area has lengthened and become of primary importance. Primary tracks are also found over North America from Kansas across the Great Lakes to James Bay, and from James Bay to the Labrador coast. From the Newfoundland-Labrador coasts, the main track is toward Iceland. Another shorter track exists, about 5° latitude south of the main track in midocean. A single track extends from south of Iceland to northern Norway. Occasionally, North Atlantic extratropical storms, being of considerable intensity, generate hurricane- or near-hurricane-force winds.

TROPICAL CYCLONES. The hurricane season continues into October, but after the middle of the month, the probability of a tropical storm occurrence diminishes rapidly. An average of 3 to 4 tropical storms will occur each 2 yr, and about half will develop to hurricane strength. The vast majority of the storms develop before the 21st of the month. Most October storms form over the western Caribbean, but some are spawned near the Lesser Antilles.

SEA HEIGHTS. During October, sea heights of 12 ft or more are usually encountered 10 percent or more of the time over the open ocean north of about 40°N (excluding most of the Norwegian Sea), over the Gulf of Lions, and over central Hudson Bay. An area of 20-percent frequency extends southward out of the Denmark Strait, then eastward south of Iceland to the Faeroe Islands, and westward around Kap Farvel into the Labrador Sea. The southernmost point of the southern boundary is about 57°N, near 35°W. A second small area, about 4° in diameter, is centered near 50°N, 40°W. The areas described above very closely approximate the 10-percent frequency for waves of 20 ft or greater.

VISIBILITY continues to improve during October, compared with the previous month. Frequencies of 10 percent or more of visibility less than 2 mi are now found in only three scattered areas--the southern Davis Strait and northern Labrador Sea, over waters due east of Newfoundland, and from the southern reaches of the Denmark Strait southeastward to the Faeroe Islands and then north-northeastward to the Greenland Sea. As in September, the cold waters north of Iceland entertain an area of 20- to 30-percent frequency of visibility less than 2 mi, and a small area (within this larger area and centered near 68°N, 18°W) where visibility less than 2 mi exceeds 30 percent of all observations.

## NORTH PACIFIC, OCTOBER

WEATHER. October marks the transition to winter conditions over the northern latitudes of the North Pacific. The Aleutian Low, lying off Cape Newenham, Alaska, has deepened 4.5 mb (as compared to September) to 1002.5 mb, while the subtropical High has become a flat east-west ridge, centered roughly along the 33d parallel, containing a maximum pressure of about 1020 mb.

WINDS. Between 40° and 60°N, westerly winds predominate, with forces 4 to 6 most frequent. However, northwesterlies and northerlies prevail over the eastern Bering Sea, easterlies dominate the Gulf of Alaska, and winds off the coast of British Columbia normally blow from the southwesterly quarter. North of 60°N, the winds are northerly to northeasterly at force 3 to 5. From 30° to 40°N, directions are more variable, with northeasterly and northerly winds prevalent east of Honshu, and northwesterlies common east of the dateline, shifting to northerly near the California coast. Force-4 winds constitute the largest percent-

age frequency within the above latitudinal belt. The northeast trades, which average slightly less than force 4, prevail between the Equator and 30°N. Northerly force-3 winds are the general rule out from the Gulf of Tehuantepec. The winter monsoon is now well established over Asiatic waters, penetrating as far south as Indochina.

GALES. The chances of encountering winds of force 8 or higher increase appreciably in October, particularly in the middle and higher latitudes. The highest incidence of gales occurs between 48° and 56°N, from Kamchatka eastward to about 140°W, with over 10 percent of the wind observations over most of these waters revealing gales. Ships plying the central Bering Sea as far north as the 63d parallel are also laced by gale-force winds more than 10 percent of the time. There is a gradual decrease in frequency southward--gales are infrequent south of 30°N over the central ocean, 35°N over the western ocean, and about 44°N above eastern waters. Nevertheless, gales are observed between 5 and 10 percent of the time over the typhoon-troubled waters near Taiwan, and those southwest of Japan.

EXTRATROPICAL CYCLONES. The frequency and intensity of extratropical cyclones increase in October. The principal sources of storms, or cyclogenesis, are the Mongolia - Manchuria area and the seas south of Japan. Other areas are along the Aleutian Islands, and over the midocean slightly north of latitude 40°N. The primary storm tracks extend from across Sakhalin and south of Japan toward the Near Islands. From there, the track parallels the Aleutian Islands into the Gulf of Alaska. Another track comes out of the midocean source area into the Gulf of Alaska. A secondary track departs the Near Islands for the Bering Strait.

TROPICAL CYCLONES. Three or four tropical cyclones can be expected to develop over the tropical waters of the Far East. On the average, two or three reach typhoon intensity. Most of these tropical cyclones form at low latitudes in an area extending from the Philippine Islands to about 155°E. Their early movement is generally west-northwestward, and most recurve east of the Philippines or Taiwan and sweep up along the east coast of Japan. A smaller number move across the Philippines into the South China Sea; a still smaller number reach the Asiatic mainland.

In the tropical waters of the eastern North Pacific, tropical cyclones are less frequent than in September, averaging about two per year. Roughly half of these storms reach hurricane intensity at some time in their lives. October tropical cyclones follow less regular tracks than those of September. After developing off the coast of southern Mexico-Guatemala, or near the Revillagigedo Islands, a large percentage of these storms will move inland over Mexico, south of about 30°N.

SEA HEIGHTS. The frequency and area of high waves increase, especially over the northern shipping lanes. The area bounded by approximately 43°N, 160°E, 145°W, and the Aleutian Islands, has 12-ft or higher waves over 10 percent of the time. In general, the area from coast to coast between 30° and 55°N will have seas 12 ft or greater, 2 to 10 percent of the time.

VISIBILITY. Percentage frequencies of low visibility decrease in October. Visibility less than 2 mi occurs 10 percent or more of the time north of a line drawn from Ostrov Karaginski eastward to a point northeast of the Pribilofs, and then southwestward across the Fox Islands to a point near 42°N, 175°W. From there, the line extends eastward across the 155th meridian, and then northward to Kodiak Island.

## NORTH ATLANTIC, NOVEMBER

WEATHER. While normally November is considered a transitional period between fall and winter weather over northern waters, this month occasionally develops some of the severest weather of the winter season. Most rough weather is confined to north of 45°N, except along the coast of the United States, where there is an increase in winter-type LOWs. Over the Great Lakes Region, two primary storm tracks--of Alberta and Colorado LOWs--converge into an area of maximum cyclone frequency, contributing in a large measure to rough weather toward the close of the Lakes' navigation season. The Icelandic Low (1002 mb) is still centered between Iceland and southern Greenland. The Azores High has shifted eastward and is centered near 33°N, 29°W; its central pressure has risen slightly to about 1021 mb.

WINDS north of 60°N are quite variable at about force 4 to 5, although these winds tend to come from the northerly quarter west of Iceland, and from the southerly quarter east of that island nation. Westerly winds, force 4 to 6, prevail over most of the ocean between 40° and 60°N. Between the latitudes of 30° and 40°N, force 3 to 4 winds are of variable direction, except east of the Azores, where a noticeable northerly component prevails. The northeast trades, averaging force 3 to 4, extend from 30°N southward to 10°N. Between 10°N and the Equator, southeasterlies (force 3) are predominant.

GALES. The frequency of gales over northern and middle latitudes increases substantially in November. Winds of force 8 or higher occur 10 percent or more of the time over most areas north of about 35°N over western waters; north of about 40°N over the central ocean; and north of about 44°N over eastern waters, including the southern half of the North Sea. A 10-percent frequency of gales is encountered on the Mediterranean only over the Gulf of Lions. Frequencies are generally less than 10 percent, however, over the waters between Iceland and southern Greenland (near the center of the Icelandic Low), over a relatively small area about 200 mi northwest of the western Irish coast, and over and south of the Irish Sea. Frequencies of 20 percent or more occur in the Davis Strait north of 63°N, south of Greenland in the vicinity of 55°N, 45°W, and over most of the Greenland and Norwegian Seas.

EXTRATROPICAL CYCLONES. The principal track of extratropical LOWs is northeastward from the waters off Cape Cod, across Newfoundland to Iceland, and then through the Norwegian Sea. Sometimes these

cyclones will approach Iceland from the central part of the North Atlantic Ocean. Other major tracks lead from Hudson Bay to the Davis Strait, and from the Gulf of Lions to Italy.

TROPICAL CYCLONES are infrequent in November. Usually, one storm in 3 yr may be expected, and about half will develop to hurricane intensity. Most of these storms develop over the Caribbean Sea or eastern Gulf of Mexico, and are soon following a northeasterly path out over the main body of the North Atlantic.

SEA HEIGHTS of 12 ft or more are encountered more than 10 percent of the time on most of the ocean north of about 40°N and south of the Davis Strait and the Norwegian Sea, and on the Mediterranean Sea in the Gulf of Lions and the northern Aegean Sea. The frequency increases to 20 percent or more over most of the waters between 47° and 60°N, and extending into the Denmark Strait.

VISIBILITY less than 2 mi reaches a frequency of 10 percent north of a line drawn from the waters around, and 200 mi south of, Kap Farvel west-northwestward to Saglik, Labrador (55 mi northwest of Cod Island); and north of another line extending from Angmagssalik, Greenland, to northwestern Iceland, then across land to the Vesturhorn (eastern Iceland), then eastward to 64°N, 07°W; it then stretches north-northeastward across the Norwegian Sea to the waters north of Norway. An area of frequencies exceeding 20 percent or more lies north of Iceland between 67° and 72°N, and westward from 05°W to Greenland.

## NORTH PACIFIC, NOVEMBER

WEATHER. November is often a stormy month north of 35°N over western waters, and about 40°N over the eastern ocean. There have been years when November was the stormiest month of the winter season, but generally the weather is not too severe, and there may be quiet periods lasting several days. South of 40°N, the probability of severe extratropical storms diminishes rapidly with latitude. During November, the Aleutian Low, near 57°N, 170°W, is well established over northern latitudes, with a central pressure of 1000 mb. The Pacific subtropical High, at 1021 mb, is slightly stronger than in October and is centered near 33°N, 140°W. Off the Chinese coast, pressures are higher than during October because of the buildup of the cold Asiatic High.

WINDS. Over the ocean north of 55°N, northerly winds (force 4 to 6) prevail, except over the eastern Bering Sea, where winds are variable, and the Gulf of Alaska, where easterlies and northeasterlies are most common. With the exception of the area east of 140°W, where southerly and westerly winds are prevalent, westerly winds (force 4 to 6) predominate between 55° and 35°N. Variable winds near force 4 are most frequent between 35° and 25°N, except over the Yellow Sea and waters off Japan, where northerlies predominate. The northeast monsoon (affecting areas west of 140°E) and the northeast trades blow steadily at about force 4, south of 25°N. Lighter force 2 to 3 winds are the rule over the southern limits of the South China Sea, east of the Gulf of Siam. Northerly winds blow steadily out from the Gulf of Tehuantepec, off Mexico's south coast. They reach gale force between 5 and 10 percent of the time just west of the gulf.

GALES occur 5 percent or more of the time north of about 35°N. An area of 5- to 10-percent frequency is also found over the northern reaches of the South China Sea, including the Formosa Strait and the Luzon Strait, and west of the Gulf fo Tehuantepec, as mentioned above. Actually, a frequency of 10 percent or more is found over most of the waters north of 39°N, with the exception of the eastern Pacific east of 154°W (south of 50°N) and the waters east of the Kamchatka Peninsula. A small area of maximum frequency, where gales occur 20 percent or more of the time, is centered about 225 mi southeast of the southern tip of Kamchatka.

EXTRATROPICAL CYCLONES. The main storm tracks extend northeastward from the Japanese Islands to the western Aleutians, and then east-northeastward to the Gulf of Alaska. Another primary cyclone track enters the gulf from an area in the central ocean near 47°N, 169°W. In November, there are more LOWs passing over the Gulf of Alaska than any other part of the Northern Hemisphere; this is also true of 5 of the following 6 mo.

TROPICAL CYCLONES. On the average, two or three tropical cyclones develop over the western North Pacific in November. Two of these usually reach typhoon intensity. The region of most frequent formation is in the vicinity of the central and western Caroline Islands; the tropical cyclones either travel west-northwestward over the Philippines and the South China Sea, or recurve near 15°N, 132°E, to pass east of the Japanese Islands.

Tropical storm frequency over the eastern North Pacific drops rapidly for November, averaging about one every 3 yr. None have developed to hurricane intensity. Tropical storms very seldom occur in the central North Pacific--maybe one every 20 yr. When these late-season storms do develop in the eastern ocean, their direction of movement is usually more northerly than westerly.

SEA HEIGHTS. The area with 12-ft or greater seas and a frequency of 10 percent is bounded by the Aleutian Islands, 158°E, 43°N to 160°W, where the latitude drops to 35°N, and a line from 35°N, 150°W, to the Queen Charlotte Islands. A small area between Hong Kong and Taiwan is also affected, as is a large part of the Sea of Okhotsk. High-swell observations are found north of 30°N, with a tongue extending to the Equator east of the Hawaiian Islands. These observations are more frequent off the State of Washington coast, south of Kodiak Island, and east of the Kuril Islands.

VISIBILITY. Frequencies of low visibility (less than 2 mi) greater than 10 percent lie north of a line drawn from Mys Terpeniya, Sakhalin, eastward across the central Kurils, and then north-northeastward to the waters east of the Komandorskiye Islands. From there, the line stretches northeastward to St. Lawrence Island and the Seward Peninsula. Two smaller regions of 10-percent or greater frequency are centered over the Bering Sea, near 54°N, 173°W, and over the midlatitudes of the eastern North Pacific, near 46°N, 146°W.

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